One size fits all? Female Headed Households, Access to Resources and Labor Supply to Farming in Kenya*

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Abstract

The goal of this paper is twofold as it aims (i) to investigate whether female headed households (FHH) can be distinguished by patterns of production and (ii) to look for the underlying causes of productivity differentials between FHH categories. Studies dealing with the question of productivity in FHH and male headed households (MHH) find that FHH are either less, equally, or more productive to MHH which is often explained by differences with respect to access to productive resources as land. To reconcile these findings, I propose a new way to analyze gender differences in farming that can be generalized to farm household characteristics other than the sex of the head of household. The basic idea is that both tenure insecurity and the risk of falling short of income, e.g. falling below the poverty line, affect the supply of labor, but they do so in opposite directions. That is, while tenure insecurity tends to decrease labor effort, income risks increase it as subsistence farmers want to avoid falling (deeper) into poverty. Depending on which of these risks prevails in the perception of farmers, they become more or less productive than a benchmark farmer who faces none of these constraints. The empirical results establish (i) that FHH are a very heterogeneous household category which need to be distinguished when analyzing issues of productivity and (ii) that FHH facing tenure insecurity are less productive compared to MHH. However, this result only obtains in case households are not at risk of falling into poverty. If they are, FHH increase labor supply to achieve a minimum level of income.

Keywords: Tenure insecurity, income risk, labor supply

1 Introduction

The goal of this paper is twofold as it aims (i) to investigate whether female headed households (FHH) can be distinguished by patterns of production and (ii) to look for the underlying causes of productivity differentials between FHH categories. I propose a new way to analyze gender differences in farming that can be generalized to farm household characteristics other than the sex of the head of household. The basic idea is that both tenure insecurity and the risk of falling short of income, e.g. falling below the poverty line, affect the supply of labor, but they do so in opposite directions. That is, while tenure insecurity tends to decrease labor effort, income risks increase it as subsistence farmers want to avoid falling (deeper) into poverty. Depending on which of these risks prevails in the perception of farmers, they become more or less productive than a benchmark farmer who faces none of these constraints. In what follows I will treat tenure security as exogenously given, while income risks can to some extent be influenced by the farmer. I will talk of the latter as a state, where farmers can shift from one state into another. It should be noted that the concept of productivity used here does not imply that farmers in rural areas of developing countries do produce on a large scale. The produced output is often only slightly above the poverty line and being (relatively) productive often simply means to produce a little bit more than in an environment that does not impose any risks on the farmer.

In the discussion on the productivity of poor farmers in developing countries, women as heads of household have received wide attention. A number of studies compare the productivity of farming systems of FHH with those of male headed households (MHH). The conclusions drawn are ambiguous, however. In some cases, MHH turn out to be more productive than FHH, as in the studies from Bindlish, Evenson and Gbetibouo (1993), Chipande (1987), Dalton, Masters and Foster (1997), and Evenson and Mwabu (1998). This shortfall in productivity of FHH is often explained by the constraints that women face regarding land rights (Doss 2001, Doss and Morris 2001). If land rights are not clearly defined and women lack secure land rights or the power to make on-farm investment decisions, investments into land improvement and productivity increasing technologies are below the production possibility frontier that defines the possible output under ideal con-

ditions, where no risk is imposed on the farmers (Chipande 1987, Saito and Weidemann 1990, Saito, Mekonnen and Spurling 1994). Soil conservation or the cultivation of cash crops such as cotton are examples for labor intensive technologies which potentially increase productivity in the long run, but where tenure insecurity leads to non-adoption (see Anim 1999, Chipande 1987, Barbier 1998, Forson 1999, Lapar and Pandey 1999, Pender and Kerr 1998, Shively 1997, Templeton and Scherr 1997).

Despite the often reproduced finding of low productivity of FHH, there are other studies reporting mixed results. In their investigation of the application of improved crop varieties Doss and Morris (2001) find that the adoption rate of hybrid maize is equal among FHH and MHH in Ghana. However, FHH were less likely to adopt modern varieties of other crops. Analyzing data from Benin and Malawi, Minot, Kherallah and Berry (2000) find that FHH in Malawi are more likely to use fertilizer than MHH. For the case of Benin, there are no significant differences. In other instances, studies report that FHH achieve the same yield per hectare or produce even more than MHH (Bindlish and Evenson 1993, Moock 1976).

In sum, it seems that there are no *a priori* statements possible on the productivity of FHH since they turn out to be less, equally or more productive compared with MHH. This paper is an attempt to reconcile the seemingly contradictory empirical findings through incorporating tenure insecurity and the risk of remaining below the poverty line into a simple farm decision model. Further, the empirical analysis that follows explicitly accounts for the ambiguity of the FHH concept as different types of FHH operate under substantially different circumstances and thus are exposed to different kinds of risks.

A common prediction on how farmers who are risk averse respond to income risk, as it is induced by tenure uncertainty, is that they reduce effort and investment, i.e. they produce a lower amount of output as compared to if they were risk neutral (Feder, Just and Zilberman 1988, Besley 1995). The underlying theory has been provided by Sandmo (1971) who introduced price uncertainty into the decision horizon of a competitive firm and demonstrated that firms respond to uncertainty by reducing output. However, this theory has serious shortcomings when applied to the context of subsistence farming in developing countries, where part of the output is consumed by the producers and where farmers cannot afford to reduce effort since lower

output implies they would fall into even deeper poverty. Early concerns about the applicability of Sandmo's model to subsistence farming are stated by Finkelshtain and Chalfant (1991) who theoretically demonstrate that depending on the share of home consumption and the income elasticity of household demand for the subsistence good, farmers may well produce more when exposed to income risk. They also find that the common Arrow-Pratt measure of risk aversion falls short in measuring the true risk aversion of subsistence farmers.

The theory developed in this paper as well as the subsequent empirical analysis establish that how farmers respond to the risk associated with tenure insecurity depends on the availability of alternative income options which guarantee a certain level of income. A major finding presented here is that farmers switch between two different states which are determined by the probability of falling short of income. If this risk is high, farmers cannot afford to adjust their production to other risks like tenure insecurity as they otherwise would be even poorer. On the other hand, when the risk to fall into poverty is relatively small, farmers respond to tenure insecurity by reducing production. This they do at an increasing level, the farer they get ahead from their subjective poverty line.[1] The mixed results concerning the productivity of FHH in comparison to MHH may therefore be explained by their different exposures to income risk.

All studies concerned with comparisons of agricultural production between FHH and MHH neglect the fact that the concept of a FHH is multifaceted and not easily subsumed under a single heading. As previous studies have shown, it is possible to distinguish between different categories of FHH according to a number of criteria as for example the marital status of the head of household, whether a woman is the household decision maker or the main income earner, etc. By choosing one of these criteria, it is possible to derive different implications for the welfare of FHH and its associated categories (Drèze and Srinivasan 1997, Fuwa 2000, Kennedy and Peters 1992, Rosenhouse 1989). However, these categories can also be related to constraints and risks involved in farming that are specific for certain kinds of FHH. The nature and distribution of these constraints across differ-

[1]The risk of falling short of income is at least partly a subjective risk as it depends on the personal perception of being poor or not. This is the reason why I am not referring to an explicit poverty line in the empirical section.

ent FHH categories imply that depending on the type FHH should exhibit different patterns of production which are in the focus of this paper. These constraints are determined by the marital status, demographic characteristics and the status of a woman as being the main household decision maker. Depending on these characteristics, the FHH's status of land rights varies, implying that tenure security is determined by the status of the woman.

Tenure insecurity is not the only risk that women as heads of household are facing. Outmigrating husbands often leave the household and literally take the farm decision power with them, such that women are not allowed to do any on-farm investment decisions or crop choices. In what follows, I treat tenure insecurity and low levels of decision making competence interchangeably as they imply the same conclusion regarding the incentive structure to invest in productivity increases.

Although the studies cited above address the welfare implications arising from different forms of FHH, as yet no study was done on the production side of FHH in smallholder farming in sub-Saharan Africa. Using a large scale household survey from Kenya which provides detailed information on household characteristics and farming, I distinguish between eight different categories of FHH and investigate whether these household categories are sufficiently different to exhibit household specific patterns of production arising from different sets of constraints these households are subjected to.

2 The problem of classifying FHH

The most common way to classify FHH is self-reported headship which is a standard question in most household surveys. Usage of this indicator in empirical studies is based on the assumption that FHH are a homogeneous group, thus ignoring that there are many ways out of which a FHH can emerge and according to which FHH can be categorized. One possible further classification is marital status, which includes marriage, widowhood, or divorced women. Another category may be demographic characteristics of the household. A significant number of FHH result from temporary outmigration of the husband, seeking employment in urban areas. Another example is polygamy which is still a wide spread pattern of family organization in sub-Saharan Africa. Polygamous households are often part of a larger household compound which is not necessarily captured by household

surveys. Such a household may be identified as a FHH, although it belongs to an array of different but related household units where usually a man is responsible for household decisions. It is likely that such households operate under entirely different conditions as compared to widows or unmarried women.

These criteria, though important means to identify different categories of FHH, do not comprise further interesting cases. Many FHH are characterized by the fact that men are entirely or in part responsible for on-farm decision making while in other cases women are the sole decision makers. Kennedy and Peters (1992) have classified these groups as *de facto* and *de jure* FHH, where only in the latter the woman is considered to be the legal and customary household decision maker. A *de facto* FHH on the other hand is characterized by a man who lives in the household but is absent most of the time. Women in these households are married but are not necessarily the principal household decision maker.

Before classifying FHH, it is necessary to ask for the specific constraints that women face. Women in many sub-Saharan African countries are disadvantaged in terms of access to land, which translates into difficulties to obtain credits and therefore agricultural inputs (see Gopal and Salim (1998) for an extensive review of women and land rights in Eastern Africa). In some cases, women are not allowed to register land in their names and are thus dependent on a male relative, be it their husband, father, brother, son, etc., who can hold a title for them. Even where legal reforms have brought about the right for women to possess land as in Kenya, men often registered all household land in their names, even if it customarily belonged to the woman. If the owner of the land title dies or separates, the woman may lose access rights to land as the titles are often passed to a male member of the family. This makes tenureship uncertain which affects productivity as the farmer cannot be sure to retain all returns from land and thus has few incentives to invest in land improvements and inputs (Feder et al. 1988, Besley 1995).

Land that is not entitled in the farmer's name cannot be used as collateral to obtain credits, which inhibits the adoption of improved crop varieties and complementary inputs. This has been found to be a major reason why women tend to be excluded from credit programs (Saito et al. 1994). Failure to adopt modern technologies would therefore arise not necessarily due to a generally imperfect input market, but as a consequence of characteristics

inherent to the social status of women farmers. Another reason is the reluctance of extension workers to visit women such that women are further constrained with regard to information (Doss 2001, Doss and Morris 2001). Finally, men may be important for establishing business contacts and are often responsible for marketing cash crops. In rural Kenya, men often serve as middlemen between women and the market for capital goods and agricultural inputs (Savane 1986).

Whether a woman as head of household faces such constraints depends on the way out of which the female headship has emerged. The death of the husband is an exogenous shock that immediately changes the woman's economic and social position. In many patrilineal societies this implies that access to land becomes more insecure. This holds also for the case of Kenya where, although land is legally a private property that can be sold, the major means to access land is through the family. Among the Kikuyu, who constitute the largest ethnic group in Kenya, land is alloted along patrilineages, where the 'guardian' of the lineage assigns land to the sons. This is mostly done upon marriage, but can also happen before. The married son who receives the land is obliged to give a certain share of the land to his wife such that marriage guarantees access to land for women. A woman is excluded from inheriting land. Even though the Kenyan law has by now legalized the bequest of land to daughters, most family elders give the land to sons (Davison 1988).

Under the British colonial rule, land entitlements have been introduced in the course of the Swynnerton Plan that came into law in 1954. The major aim of the plan was to reform the land ownership system by introducing a formal land entitlement system in order to induce agricultural development through setting proper incentives.[2] A result of this effort was that many men took the chance to register all family land in their names. Even though, their wives were formerly granted land for cultivation, women had no possibility to claim that land legally. Consequently, the major means for women to access land is marriage.

Within marriage, however, women's access to land is secure and land cannot be taken away by the husband. The woman also often exercises the right to control the produce of the land and to decide what to crop

[2]Although the Swynnerton plan was launched in 1954, its implementation is still ongoing as a lot of land has not yet been registered.

and what to sell. Hence, as long as the conjugal arrangement holds, land rights are well defined, but if marriage ends, the woman's access to land becomes at risk. In case of separation or if the husband dies, the family of the husband often claims back the land which they have initially given to their son. This may even happen years after the passing of the man, in case he had a younger brother and the parents become in need to give out land. If the woman happens to become a widow, often a brother of the deceased husband takes over farm decision making. 'Formally', the husband's family therefore still holds the land rights, but for the widow this implies that she is granted a means of survival, for the brother as the 'representative' decision maker guarantees that she can keep the land (Davison 1988).

In some other cases, the widow or separated woman may cultivate the land on behalf of one of her sons or brothers, which puts her into the same position as if a relative of the passed husband took over decision making power. Unmarried women may receive land from their father which enables these women to form an independent household. However, these women may not have control rights over the land because the father often keeps control such that in case one of his sons marries, he still has land at his disposal to give to his son (Davison 1988, Yngstrom 2002). Men on the other hand do not face such difficulties as tenure insecurity as they are favored through the traditional land distribution system.

Although the examples bear some specificity for Kenya, it is easy to find examples from other ethnic groups other than the Kikuyu either in Kenya or other Eastern African countries where mechanisms of land allotment and marriage are very similar (for further examples and references see Davison 1988, Gopal and Salim 1998, Yngstrom 2002). The constraints of widows bear similarity to those women left by their husbands (Gopal and Salim 1998). However, women may also seek divorce. This decision may be driven by the consideration that she can achieve a higher level of welfare outside marriage. Using data from Jamaica, Handa (1996) finds that some women gain more from staying unmarried since they have independent access to resources. Regarding divorce, women may seek separation only when having secure access to land and exerting full decision making power.

Another widespread phenomenon is the temporary out-migration of husbands seeking employment in urban areas. In Uganda it has been found that husbands—although absent—maintain the decision making power even

when they are away from home over extended periods.[3] Asked why they did not apply improved farming technologies, the women responded that they do not have the right to make decisions about investments (see also Kennedy and Peters 1992). In these households, men often still play a dominant role in household decision making while the woman is not allowed to decide about important on-farm investments.

The different examples cited give a guideline along which one may construct several different classes of FHH, dependent on their marital status and the presence of a man who affects household decisions and determines tenure security. A widow who receives support from her sons is not exposed to the same constraints as a widow who needs to argue with her husband's family about the land. A FHH which emerged out of temporary outmigration is cropping under different constraints when the man still keeps the right for on-farm decision making compared to such households where the woman is fully responsible. All these different situations imply different constraints which affect agricultural production and thus lead to varying levels of productivity. The model developed in the next section aims to account for the heterogeneity of the overall FHH category while explaining the observed ambiguity of productivity levels of FHH.

3 The model

In order to derive the conditions under which FHH exhibit either higher, equal, or lower levels of productivity compared with MHH, I construct a household optimization model that allows for investigating labor supply decisions under two different states. The one state is achieved when the household's income is above the subjective poverty line. In this case, the standard model as the one by Sandmo predicts that risk averse farmers would reduce their labor supply when exposed to tenure uncertainty. As argued in the previous section, the level of tenure uncertainty is determined by the woman's status, that is, whether she has a high or low degree of bargaining power, whereas high levels of bargaining power are associated with greater tenure security. On the other hand, in the second state, farmers face the risk of falling below the poverty line that changes their response to tenure uncertainty. Reducing effort is not an option as it would imply becoming even

[3] I am thankful to John Pender for pointing this out to me.

poorer and more deprived. In order to escape that trap, farmers need to increase labor effort to make sure that they do not fall deeper into poverty. As shown by the Kenyan data, the returns from smallholder farming are extremely low. The only option to escape poverty in the short run is thus either to increase labor supply or to engage in off-farm income activities. The latter is proves to be difficult for many households in rural areas where the participation in the off-farm labor market is below 50 percent (see also table 7 further in the text). A major result of the model developed below is therefore that tenure insecurity does not necessarily lead to a reduction of labor supply, depending on which perception of risk prevails: (i) tenure uncertainty or (ii) the risk of falling short of income. The model is kept simple and considers only labor as essential variable input. However, the model is generalizable to all other inputs such as fertilizer, pesticides or draft power as well. Land, the second important input, is considered fixed throughout the following analysis.

I first start with a simple framework in which utility is maximized under perfect security, which will be extended later in the text. The female head of household is endowed with a fixed amount of labor time T which she allocates across two different income generating activities: crop cultivation and off-farm work. If the woman has the opportunity to generate off-farm income she receives a wage rate w so that her off-farm income will be wl, where l denotes her off-farm labor supply. This activity does not need to be restricted to denote only wage labor, but w may also represent marginal returns to off-farm enterprises. Land A is cultivated using labor $T-l$ which gives rise to a production function of the form $q = f(T-l, A)$ for which it is assumed that $f' > 0$ and $f'' < 0$, where f' and f'' denote the first and second derivative of f with respect to l. Each activity of the woman involves a cost which is captured by a function c_w and c_f respectively, which share the usual properties of a cost function, that is $c' > 0$ and $c'' > 0$. The costs arise from the disutility of labor. Alternatively, one may think of more sophisticated representations where the costs in c_w arise from searching for a job, transportation, etc., or from purchasing inputs for off-farm enterprises. Equivalently, one may extend c_f to include the needs to purchase seeds, fertilizer or pesticides without substantial complication and without changing the basic results. However, for reasons of simplicity I focus on labor supply only and thus the only variable driving the cost function is l. Combining

the productive activities with the cost functions, the woman faces an income given by

$$y = wl - c_w(l) + f(T - l, A) - c_f(T - l) \tag{1}$$

This equation describes the situation of a farmer who does not encounter any constraints other than her disutility and restrictions implied by wage rates and the technology applied. To capture tenure insecurity, I introduce the variable $\pi(\theta)$ which is the probability that the woman exercises full land rights and can retain the land in case of the death of her husband. Since π is a probability, $0 \leq \pi \leq 1$ holds and when multiplying π by $f(\cdot)$ we obtain the expected returns to farm production. The probability π or the level of tenure security depends on the woman's level of bargaining power as she needs to defend her land against the claims of her husband's family. It is convenient for the subsequent analysis to assume that the bargaining power parameter θ directly translates into π such that $\theta = \pi$. If the woman has the means to defend the land against claims of her husband's family, that is, if θ is equal to or close to 1, then she faces a high level of tenure security. Note that in the present framework π does not necessarily need to represent tenure security, but may equally denote the power to make on-farm investment decisions in case of absent husbands. In this regard, θ can also be interpreted as the power to exert the right to decide.

The second modification concerns the probability that households only achieve a level of income below the poverty line. Very poor households need to define an income target that ensures a minimum welfare level, such as the satisfaction of a minimum level of nutrition, basic needs, etc. This income target is somewhat different from the usual notion of an income target that implies a backward bending labor supply curve where the target works as a threshold. In target income models, workers do not want to supply more labor, but value leisure higher than additional income, once the threshold has been achieved.[4] In the present setting, target income rather refers to a different concept, that is, farmers facing the risk of not achieving their minimum acceptable income, supply more labor in order to get as close as possible to the income target. Hence, households at risk of falling below their income target cannot afford to work less and thus exhibit a different cost function as compared to a wealthy household. Let the probability that

[4]See Camerer, Babock and Loewenstein (1997) and Farber (2005) for investigations on target incomes and labor supply.

a woman achieves her target be given by

$$p = \frac{1}{F(P) - F(0)} \int_0^P f(y)dy \tag{2}$$

where P is the target minimum acceptable income (for convenience one may think of P as the (subjective) poverty line), $F(\cdot)$ is a cumulative distribution function, $f(\cdot)$ is the associated probability density, and y is income.[5] Since y is a function of available land size A, returns from market labor w, total availability of labor time T, but also of bargaining power θ, we can write p equivalently as $p(A, w, T, \theta)$. p is the realization of a cumulative distribution function and is assumed to be increasing in all of its arguments. For instance, with rising wage rates, income increases as well as more labor is allocated to off-farm activities, which in turn increases the probability to achieve the income target. In the model below, the variable p affects the shape of the cost functions which flatten when p approaches zero.

Combining tenure insecurity and the probability to achieve the income target with (1) we get the program of the FHH

$$\begin{aligned} &\max_y \quad u(y) \\ \text{s.t.} \quad &y = wl - pc_w(l) + \theta f(T - l, A) - pc_f(T - l) \end{aligned} \tag{3}$$

Maximization of (3) with respect to l generates the conditions for optimal labor allocation across the two activities

$$w = pc'_w + [\theta f' - pc'_f] \tag{4}$$

Women allocate labor such that the going market wage rate equals the marginal cost of working plus the difference between marginal returns from labor and the marginal costs from farming. After solving for l, optimal labor supply can be expressed as a function of θ and p, as well as of A and w. Denote optimal labor supply as $l^*(\theta, p, A, w)$. Applying the envelope theorem with respect to θ gives

$$\frac{\partial l^*}{\partial \theta} = \frac{f' - p'c'_f + p'c'_w}{\theta f'' - pc''_f - pc''_w} \tag{5}$$

[5]Note, that this expression is derived from a truncated density function which is truncated at P.

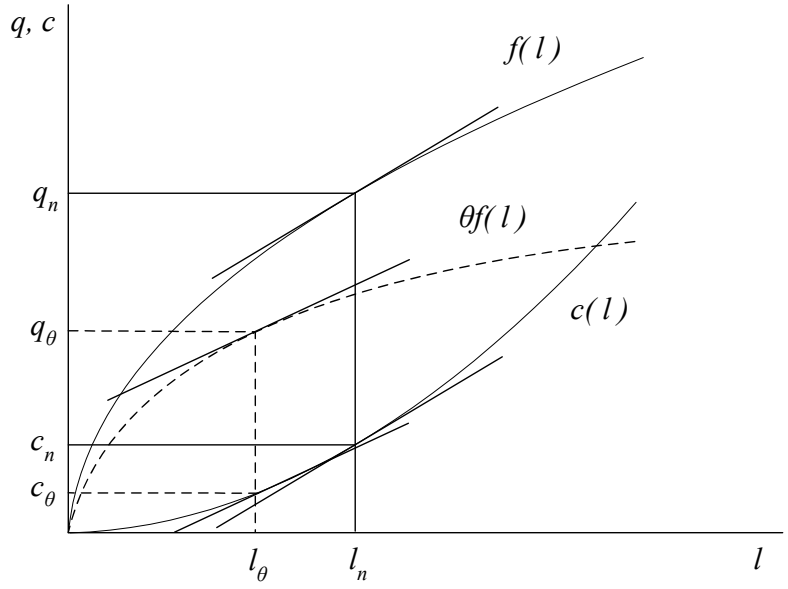
The numerator of the right hand side is positive as it is a scaled version of the right and side of (4) which is positive, since $0 \leq p' \leq 1$. The denominator is negative, because $f'' < 0$, $c''_f, c''_w > 0$. Thus we have

$$\frac{\partial l^*}{\partial \theta} < 0 \tag{6}$$

Since l^* represents optimal off-farm labor supply, a negative sign of (6) implies that FHH increase farm labor once the level of tenure security improves. The results demonstrate that land is underutilized as long as income from farming is insecure. This effect is illustrated in figure 1. The upper solid concave line denotes production where $\theta = 1$ and full tenure security is achieved. The disutility or cost function is given by the lower convex curve. Labor is allocated until the farmer's marginal productivity, depicted by the tangent on the production curve, equals her marginal costs, depicted by the tangent on the cost curve, such that optimal labor supply amounts to l_n which translates into production outcome q_n. If tenure is insecure, that is, when $\theta < 1$, expected output decreases while generating a new production frontier which is illustrated by the lower dashed concave curve. As a response to lower expected returns, the woman adjusts her optimal labor supply until the two tangents representing marginal productivity and marginal cost are just parallel. Thus she reduces effort from l_n to l_θ in order to equate marginal cost and the marginal productivity arising from the lower expected returns. This reduction of effort results in an accompanying decrease of output from q to q_θ which establishes the result that with $\theta < 1$ outputs decrease.

A similar effect running from p to labor allocation and production outcomes, but with the contrary implication, is shown in figure 2. Here the upper solid convex curve depicts a cost function that represents the case where the farmer faces no risk of falling short of income. Thus, she can equate her marginal productivity to her marginal disutility of labor which implies labor supply l_n which leads to production outcome q_n just as in the previous graph. Now assume the household faces an income risk through decreasing off-farm incomes which is expressed by values of $p < 1$. In this case, p depresses the cost curve downwards as is exemplified by the lower dashed curve. In adjusting to this income risk farmers equate their marginal productivity to the marginal cost of the new disutility function implying that in

Figure 1: Effects of θ on labor allocation



optimum costs shift from c_n to c_p where costs are given by the vertical axis. In the new equilibrium the household supplies l_p units of labor and achieves output q_p. Hence, if tenure is secure and only p varies, then farm labor supply and consequently production outcomes increase with decreasing p.

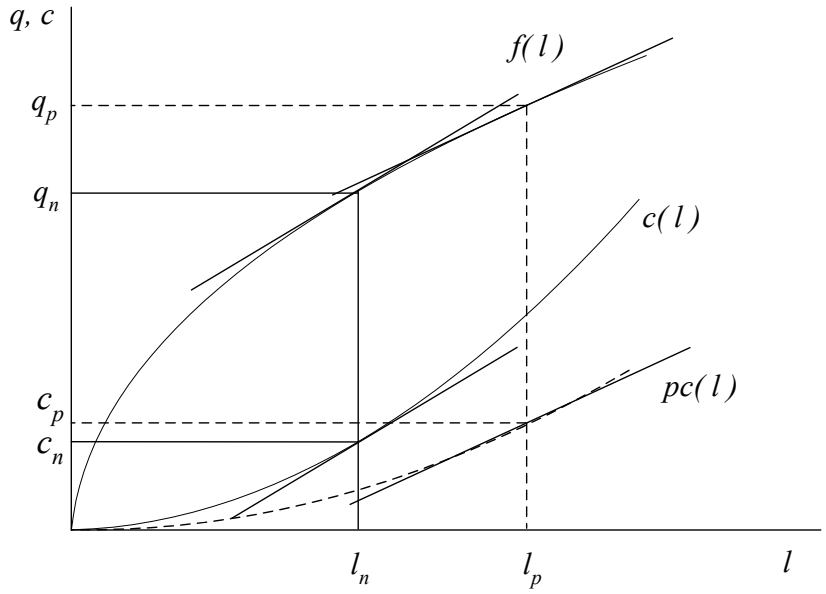
The comparative statics regarding the change of the return from off-farm employment yield

$$\frac{\partial l^*}{\partial w} = \frac{1 + p'c'_f - p'c'_w}{pc''_w + pc''_f - \theta f''} \tag{7}$$

Expression (7) is positive as long as the marginal disutility of labor in farming c'_f is larger than the marginal disutility from working on the labor market c'_w. This holds when labor markets are underdeveloped or wage rates are low, which are the cases I am focusing on. A positive sign of $\frac{\partial l^*}{\partial w}$ implies that labor is withdrawn from agriculture and allocated to off-farm activities if the wage rate is rising. With no other options but farming available, households would employ all labor in agriculture yielding the first order conditions

$$\theta f' = pc'_f \tag{8}$$

Figure 2: Effects of p on labor allocation



In order to analyze the impact of p and θ on farming efficiency, I focus on farming only and investigate the effects of farm labor supply in response to varying θ and p while holding all other factors fixed. To facilitate the exposition, I focus on equation 8 and neglect for simplicity the existence of labor markets. It should be noted that the general result is not affected by this simplification. However, later I introduce off-farm activities through investigating the effect of variations of the wage rate w on p. The crucial assumption is that p increases with w, which implies that households reallocate more and more labor towards the generation of income from off-farm activities—a result revealed by equation (7). To see how labor allocation and productivity is determined, I consider four cases summarized in table 1.

In case 1, the woman has achieved full tenure security and achieves target income with probability 1. That is, wage rates or land size are large enough to ensure that $p = 1$. In this case, household production is only constrained by personal disutility of labor and the household achieves average levels of productivity. Case 2 refers to women for whom tenure is insecure, implying that labor supply is below average. The FHH allocates labor such that the marginal productivity of farming equals the marginal cost. But since $\theta < 1$,

Table 1: Different cases with missing labor markets

Case 1	$f' = c'_f$	$\theta = 1;\ p = 1$	Average efficiency
Case 2	$\theta f' = c'_f$	$\theta < 1;\ p = 1$	Below average efficiency
Case 3	$f' = pc'_f$	$\theta = 1;\ p < 1$	Above average efficiency
Case 4	$\theta f' = pc'_f$	$\theta < 1;\ p < 1$	Indeterminate

the expected marginal returns are lower compared to case 1 households, implying that marginal costs must be lower as well. Consequently case 2 households exhibit a lower supply of labor and therefore lower output. In case 3, the curvature of the cost function is flattened through the impact of the low probability to achieve the income target. Hence, labor supply must be above average and, given land and labor time T, the household produces more than a case 1 household. Finally, in case 4 both factors, tenure insecurity and low probability to achieve target income, affect labor supply decisions. The location of these households relative to the efficiency frontier depends on the curvature of the production and cost functions which is determined by θ and p. This implies that empirically this case cannot be distinguished from the other three cases when only production output is observed. Given the shape of the two functions, labor supply might be above, below or even exactly equal to case 1 households. Optimal labor supply is somewhere between l_θ and l_p as exemplified in figures 1 and 2. An appealing feature of the model as summarized by the four cases is that it allows for explaining different levels of productivity even in the absence of labor markets.

The four cases in table 1 further imply another result: with increasing w, p increases as well and the impact of tenure insecurity in case 4 becomes stronger. To see this, consider the production outcome q_m, which is the level of production of a case 4 household and define the production outcomes q_u and q_l for case 2 and case 3 as upper and lower bounds respectively. Since in households for which case 4 applies $\theta < 1$ and $p < 1$ the household's production outcome q_m is located somewhere between q_u and q_l. But with

increasing p, the case 4 household approaches and eventually transforms into a case 2 household. Consequently, q_m approaches q_u which is associated with case 2 households; household production declines. The opposite case can be constructed when p is kept fixed and one allows θ to increase.

The model shows that the farmer's response to tenure insecurity is state dependent. When the farmer faces the risk of an income shortfall, the effect of tenure insecurity is overcompensated by the effect of p and output may not be decreased at all or may even be higher as in households exhibiting the same levels of θ but large values of p. For relatively wealthier farmers, there is only a small risk of becoming poorer, which why tenure insecurity exerts its full effect in decreasing production. That is, with given bargaining power θ and given probability p to achieve target income, FHH are either more, equally or less efficient compared to a MHH.[6] Using the model it is possible to explain the seemingly contradicting findings from the various empirical studies that have been concerned with agricultural production and the comparison of FHH and MHH. These findings have implications for empirical studies as well: the different states can only be identified when the levels of θ and p are appropriately controlled for.

4 The data

The data used in this study stems from the Kenyan Welfare Monitoring Survey III, which has been conducted during 1997 and covers more than 11,000 households. However, due to a large number of missing responses on agricultural inputs and urban households not engaged in agriculture, the total sample size reduces to 4,088 observations. The FHH indicator relies on self-reported headship to achieve comparability with other studies. The data allows for distinguishing different categories of FHH according to the three criteria (i) marital status, (ii) demographic characteristics and (iii) main household decision maker. Marital status, which is a standard question in most large scale household surveys, is probably the most obvious feature to categorize FHH. The questionnaire includes the following categories: married, never married, widowed, divorced or separated, and

[6] In principal it is possible that a MHH correspond to a case 1 or case 3 household. However, it is assumed that there is no characteristic other than low off-farm incomes that is systematically related to case 3. So, when joining all MHH within a single category, MHH must be on average more productive compared to a FHH to which case 3 applies.

whether the household is part of a polygamous household compound. In almost all households of the married category, no husband is currently staying at home and thus these are named henceforth *Temporary*. A second category covered by the data is whether the woman is divorced or separated. For this category it would be desirable to know who initiated the separation as it may affect the results, since women who seek divorce may be well prepared to live outside the household (e.g. through land ownership, wage employment, etc.). Women who have been left by their partners might be in a much less favorable situation (Gopal and Salim 1998). Divorced women are termed *Divorced*. The next category are widows who are named accordingly. Women who have never been married are called *Single* and finally women from polygamous households are classified *Polygamous*. It would be desirable to distinguish single women according to their choice of being unmarried, that is, whether land endowment has influenced the choice not to marry. Although, of the single women in the sample, only four indicate that a male non-relative resides permanently in the household, this does not imply that these women do not have a male partner. The partner may just not live with the woman in the same household.

The final characteristic used for classifying FHH refers to the main household decision maker, which determines the categories *de jure* and *de facto* FHH, whereas in the former category, women are considered as having control over household decisions while the *de facto* category denotes FHH in which not the woman does on-farm decisions but a male relative. The questionnaire contains a question on who decides on farm investments. The answer is taken here as an indication of the true head of household: FHH where the woman is responsible for farm investments are allocated into the *de jure* category and classified as *de facto* otherwise. Note, that these categories do not immediately imply the status of bargaining power, which is determined only in combination with marital status. In total, eight different categories emerge from applying these categories to the data. The different classes mainly arise from distinguishing the marital status with respect to *de jure* or *de facto* FHH. To facilitate exposition the categories are abbreviated *DJ* and *DF* respectively.[7] Only unmarried and polygamous households are

[7]There are 28 households in the *DF Temporary* category who indicate that a husband is present. This seems to be unusual and may be the result of misreporting. Excluding these household leaves the results unchanged. When forming an extra category of these households, the new category exhibits the same signs and levels of significance as the *DF*

treated as special cases and are not further categorized according to the decision maker.

The meaning of the terms *de jure* and *de facto* FHH as applied in this study does not entirely correspond to its common use (see Kennedy and Peters (1992) for an early application). The category *de jure* is usually used to classify widows, divorced and separated, as well as single FHH, while *de facto* refers to households where the woman is married but her husband is mostly not present. However, the terms are used here to further distinguish these FHH categories, as the sole application of the *de jure* and *de facto* categories fall short of fully capturing the true household decision maker.

Finally, it is necessary to analyze the levels of bargaining power of the women from the respective household categories. As in the previous section, the term bargaining power is only used for brevity and should not be taken literally, as *DF Temporary* are not threatened to lose their land, but are characterized by low levels of decision making power. Since the absent husbands still aim to control farm investments, these households are characterized by low levels of bargaining power. *DJ Temporary* households on the opposite fully control farm investments and hence exhibit high levels of θ. Among widows, those with male support, that is, where a male relative has the principal right to decide on farm investments, have a better bargaining position than their counterparts, where the woman is fully on her own. Thus, *DF Widows* have high levels of bargaining power while *DJ Widows* are at permanent risk that the husband's family claims back the land. Table 2 gives an overview to the bargaining power position of the different household categories. The question marks in the table indicate that levels of bargaining power and hence that of efficiency cannot be unambiguously determined *a priori*.

Table 3 shows the different classifications in terms of absolute numbers and shares of the sample. The share of FHH amounts to 34.4 % of the total sample. Widows add up to the largest category and account for 49.1% of all FHH, while 32.7% are *Temporary* FHH. The large share of *DJ Temporary* indicates that labor migration is a frequent cause for the emergence of FHH in general. The other household categories, *Divorced*, *Single*, and *Polygamous* are relatively small and do not account for a large share of the total sample.

Temporary category. I therefore decided to keep these households as *DF Temporary*.

Table 2: Different classes of FHH and their associated levels of bargaining power

FHH categories	Situation	Who decides?	Bargaining power
DJ Temporary	Outmigrated husband	Wife	High
DF Temporary	Outmigrated husband	Husband	Low
DJ Widow	Deceased husband	Woman	Low
DF Widow	Deceased husband	Male relative	High
DJ Divorce	Marriage divorced or separated	Woman	?
DF Divorce	Marriage divorced or separated	Male relative	?
Single	Unmarried	Woman	?
Polygamous	Polygamous	Woman or clan head	?

Columns 4 and 5 from table 3 report the average endowment with land and earned income per capita. The comparison of MHH and FHH does not reveal substantial differences regarding the distribution of land. However, when looking at the disaggregated FHH indicators some differences become apparent. All *DF* households have on average one hectare more land compared to their *DJ* counterparts. Only *DF Divorce* households have less land than the *DJ Divorce* households. Polygamous households have a land size which is above the sample average which might be due to counting all land that belongs to the compound. Regarding income, *DJ Widows* exhibit the lowest income per capita from resources other than farming, while *DF Temporary* generate the highest average income. At the time of the survey the poverty line was set at 1,297 Kenyan shillings, which is still higher than the reported average off-farm income for any of the household categories including MHH. Also, per capita income from farming is equally low. Such low incomes are reflected by the rate of poverty. It has been estimated that in 1997 about 46 percent of households in rural areas are below the food poverty line.

5 Empirical implementation

5.1 Constructing a test for the relevance of the four cases for the different FHH categories

The goal of the empirical analysis is to detect different levels of productivity among FHH which point to different exposure to tenure insecurity and low levels of decision making power. I first estimate the efficiency fron-

Table 3: Shares of FHH categories and resource endowment

	Total	Share (in %)		Land†	Off-farm inc.†	Farm inc.†
		of total	of FHH	(in hectare)	(in Kenyan shillings)	
MHH	2680	65.56		3.0	465.00	1093.75
FHH	1408	34.44		3.0	333.33	807.78
DF Temporary	143	3.50	10.16	2.0	300.00	914.36
DJ Temporary	317	7.75	22.51	3.0	800.00	744.00
DF Widow	291	7.12	20.67	2.0	250.00	1122.95
DJ Widow	400	9.78	28.41	3.0	366.67	618.14
DF Divorce	21	0.51	1.49	2.0	257.15	1395.67
DJ Divorce	63	1.54	4.47	1.5	568.7	963.33
Single	24	0.59	1.70	1.7	400.00	1806.80
Polygamous	149	3.64	10.58	3.5	375.00	797.88
Total sample	4088			3.0	400.00	933.33

†Medians reported.

tier using a variable cost function and in a second step investigate whether deviations from the frontier are systematically related to different kinds of FHH. Tenure insecurity is determined by the household's level of bargaining power, which is shown for each household type in table 4 where the first column is repeated from table 2 to facilitate the exposition of the empirical strategy. To determine where households are located relative to the efficiency frontier, a dummy variable is introduced into the cost function that accounts for each FHH category. A significant dummy implies a shift of that household category either closer to or further away from the efficiency frontier as compared to the average MHH. Given the estimation approach employed and described below, a negative result implies higher efficiency scores while a positive parameter indicates that the respective household is less productive.

Furthermore, the empirical exercise aims to discover state dependent responses to insecurity. The fundamental result of the model is that tenure insecurity exerts a different effect in each regime with implications for labor supply and productivity. Also, for households with perfect security the different regimes have efficiency implications as is evident from cases 3 and 1. The regime is determined by p, which represents the risk of falling short of income. The level of p is measured by the level of off-farm income generated by the respective household. The off-farm income is interacted with the dummy in order to determine the category specific effect. Its interpretation

is simple: when the sign is significantly positive, then with increasing income the levels of farm inefficiency increase as well because households allocate more labor away from farming toward off-farm activities. This implies an undercultivation of the available land and thus increasing inefficiency.

To be able to interpret the results, it is necessary to clarify the possible assignment of households to the four cases. Column 3 of table 4 gives an account of which FHH category can be assigned to which case. The table further contains in column 4 and 5 the signs of the dummy variables that are conform to the predictions of the theory developed in the previous chapter. By the definition of the FHH categories, the only households facing low levels of θ are *DF Temporary* and *DJ Widow* households. This implies that these households can be assigned to either case 2 or case 4. Hence, based on the theory one would expect these two household categories to be more, equally or less efficient compared to MHH, when controlling for all other determinants of productivity. Which one of these three possibilities hold is an empirical question. When the sign is negative, the household belongs to case 4 because this is the only one of the two cases that allows above average levels of productivity (see table 1). When the coefficient is insignificant, the household may also be a case 4 household due to the same reason, as the effects from θ and p may just neutralize each other.[8] When the sign of the dummy turns out to be significantly positive it is not possible to unambiguously assign the households to case 4 or case 2 as both cases allow for this option. However, as explained below, the information from the interaction term can be used to recover the case to which the household category belongs to.

DJ Temporary and *DF Widow* households are expected to be either equal to a case 1 or case 3 household as tenure insecurity does not affect them because of their high levels of bargaining power. The theory predicts that these households are either more or equally productive compared to average MHH, depending on the perception of income risk. Estimates of levels of productivity for this class of FHH are therefore predicted to be either negative or insignificant. A negative estimate means that these households are more productive than average MHH and thus are assigned to case 3. An insignificant parameter implies that there is no difference to the average

[8] An insignificant parameter may also imply that neither tenure insecurity nor low levels of p determine productive outcomes.

MHH which is assumed to be equivalent to a case 1 household. Since it is unknown whether the remaining four FHH categories have on average a high or low value of θ no expectations can be formulated beforehand.

The theory further implies that households which are initially case 3 or case 4 households can transform into case 1 and case 2 households respectively. That is, with increasing off-farm income, p is increasing and case 3 and 4 households eventually switch from one state into another. As laid out above, whether such transition exists is tested via the inclusion of an interaction term where off-farm income is interacted with each FHH category. Here again, the model implies some restrictions. Transiting from one state into another implies that households which have initially been a case 3 or case 4 household must become more inefficient with increasing incomes. That is, if a transition occurs, then the interaction term must be positive, meaning that when off-farm income activities become more attractive, more labor is allocated away from farming toward the off-farm income activity and levels of productivity decrease.

However, the theory offers even more restrictions: *DJ Temporary* and *DF Widow* can only exhibit a transition from case 3 to case 1 if case 3 households exist at all. This can easily be checked by referring to the dummy variable estimate of these households. If the dummy does not become significantly negative, there are no case 3 households and a transition cannot occur. For *DF Temporary* and *DJ Widow* this restriction does not hold, since the insignificance of the productivity estimate still does not exclude these categories from being case 4 households. However, if a transition occurs, that is, the interaction term becomes significantly positive, then an insignificant dummy variable unambiguously implies a case 4 household.

5.2 Specification of the empirical model

The economic analysis of production processes exhibits a close correspondence between theory and statistical analysis. Since the introduction of the Cobb-Douglas function in 1928, economists have developed a huge number of different functional forms with the aim to find a general function adhering to the properties derived from the theory of production. Although the Cobb-Douglas function has been widely used in the analysis of FHH farm efficiency (see Bindlish and Evenson 1993, Bindlish et al. 1993, Even-

Table 4: Assignment of cases to FHH categories and expected signs of estimates

FHH categories	Bargaining power	Possible cases	Possible sign of dummy	Possible sign of interaction term
DJ Temporary	High	1,3	0,-	0,+
DF Temporary	Low	2,4	0,-,+	0,+
DJ Widow	Low	2,4	0,-,+	0,+
DF Widow	High	1,3	0,-	0,+
DJ Divorce	?	?	?	?
DF Divorce	?	?	?	?
Single	?	?	?	?
Polygamous	?	?	?	?

son and Mwabu 1998, Minot et al. 2000, Moock 1976, Saito et al. 1994), it is restricted in its generality due to its maintained hypothesis that the elasticity of substitution equals 1 (Fuss, McFadden and Mundlak 1978). Being concerned this feature might affect empirical results, Heady and Dillon (1961) introduced a second-degree polynomial in logarithms which was a taylor series approximation to an arbitrary production function. This function contains Cobb-Douglas as a special case, as it simply adds cross- and quadratic terms to the basic Cobb-Douglas function. In a series of papers which appeared a couple of years later, Christensen, Jorgenson, and Lau (1971a, 1971b, 1974) developed the same function and named it 'translog', which has partly replaced the Cobb-Douglas, due to its flexibility and its simple implementation as it is linear in parameters and can be conveniently estimated via standard estimation techniques.

A problem which is inherent to the empirical implementation of production functions in the context of cross-sectional household data is recursive causality. In most production settings, the input quantities must be considered as choice variables, because input quantities are chosen on past experience and thus on expected output. This implies that the choice of input quantities is not independent of the level of output. However, in this case, inputs are correlated with the error term. The same can be expected for all variable inputs where the decision on the quantities is likely to be determined by the expected amount or past realizations of output. Therefore, estimates from a production function using cross-sectional data should be treated with caution as the parameters are likely to be inconsistent due

to the endogeneity of the independent variables (see Griliches and Mairesse (1998) for an extensive account of the problems involved when estimating production functions using cross sectional data).

The problem of endogeneity can be circumvented by estimating a cost function rather than a production function. When the optimization problem of the producer is reformulated such that the agent minimizes costs, given input prices, output quantities and a production technology, a cost function results. Under the assumption that farmers are price takers on a competitive market, output quantities are assumed to be exogenously given since in a competitive market the farmer chooses his output based on output prices which are exogenous as well (Jorgenson 1986). The fundamental result of duality theory is that the cost function is the dual formulation of the production function, that is, the same optimizing behavior leads to the same outcomes: minimizing costs at given prices implies maximizing production at given inputs (Fuss et al. 1978).[9] Under the assumption that the farm-households are price takers, all input prices can be treated as exogenous.

Productivity or efficiency can be decomposed into technical and allocative efficiency. However, the predictions based on the theoretical model developed in the previous section do not distinguish between the two kinds of efficiency. Higher productivity and output may be achieved by either better usage of existing inputs or by using more of one input. Therefore, to investigate the empirical content of the model, an approach is needed that can handle both technical and allocative efficiency. Other than the production function approach, the efficiency measurement embedded into a cost function is capable of capturing technical and allocative efficiency. A further advantage of the cost function is that it easily accommodates multi-output production schemes which is particularly relevant for societies dominated by agriculture as it is the case in Kenya.

In this study I focus on smallholder farming and exclude large commercial farms as these can be assumed to produce with a technology which is likely to differ substantially from those of the smallscale farmers. The median size of a smallscale farm in the sample is 3 hectares. All farms larger than the 95th percentile (22.5 hectares) are treated as large scale farms and are excluded from the sample.

[9] Given parameter estimates of a cost function it is possible to construct the associated production function (Varian 1992).

Prices are available for hired labor and draft power. Prices for family labor are computed by the approach suggested by Jacoby (1993) and Skoufias (1994) while using the number of household members working in farming. Estimating family shadow wages is necessary in order to account for the observed difference between market wages and the family shadow price for labor (Menon, Perali and Rosati 2005). The data also contains information on hourly labor supply, but this data is considered extremely noisy as it is based on recall and is subject to a large number of missing cases. Furthermore, it covers only a week and does not account for any seasonal variations. Land is considered fixed, which is a reasonable assumption as land markets are largely unavailable in rural Kenya. I further consider fertilizer, pesticides and manure used, for which dummy variables are included when the respective input has been applied.

Since most households plant a relatively large portfolio of different crops, the output quantities are divided into three major output classes: maize and cereals, vegetables and fruits, and cash crops. As further controls for the choice of technology, I include a dummy for the educational background of the head of household (primary and secondary schooling) as well as dummy variables indicating whether the household applies labor intensive irrigation. Furthermore, a dummy has been included for households which have been visited by an extension agent. The translog variable cost function used here is given by

$$\begin{aligned}\ln VC = \; & \alpha + \sum_{i=1}^{2} \beta_i \ln Q_i + \sum_{i=1}^{4} \gamma_i \ln P_i + \sum_{i=1}^{4} \delta_i \ln Y_i \\ & + \frac{1}{2} \sum_{i=1}^{2} \sum_{j=1}^{2} \phi_{ij} \ln Q_i \ln Q_j + \frac{1}{2} \sum_{i=1}^{4} \sum_{j=1}^{4} \eta_{ij} \ln P_i \ln P_j \\ & + \frac{1}{2} \sum_{i=1}^{4} \sum_{j=1}^{4} \rho_{ij} \ln Y_i \ln Y_j + \frac{1}{2} \sum_{i=1}^{2} \sum_{j=1}^{4} \psi_{ij} \ln Q_i \ln P_j \\ & + \frac{1}{2} \sum_{i=1}^{2} \sum_{j=1}^{4} \pi_{ij} \ln Q_i \ln Y_j + \frac{1}{2} \sum_{i=1}^{4} \sum_{j=1}^{4} \tau_{ij} \ln P_i \ln Y_j \\ & + \sum_{i=1}^{4} 0\kappa_{ij} D_j \end{aligned} \tag{9}$$

The variables are defined as follows:

VC:	total variable cost (hired labor, draft, power, fertilizer, pesticides)
Q_i:	quantity of fixed inputs (land, household labor)
P_i:	price of variable inputs (daily wage rate, rental rate for draft power, fertilizer price, pesticides price)
Y_i:	output quantities (maize and cereals, vegetables and fruits, cash crops, milk)
D_i:	dummy variables capturing regional characteristics

Economic theory implies that the cost function must be homogeneous of degree one in prices such that if all prices increase by a factor t, then costs must increase by t as well (see Varian 1992). This implies the following restrictions for the parameters of the translog cost function

$$\sum_{i=1}^{n} \gamma_i = 1, \qquad \sum_{i=1}^{n} \eta_{ij} = \sum_{i=1}^{n} \rho_{ij} = \sum_{i=1}^{n} \tau_{ij} = 0 \tag{10}$$

5.3 Estimation the of stochastic frontier cost function

The cost function is estimated using a stochastic frontier approach, which has been established as a standard tool for investigating the production of cost efficiency (Kumbhakar and Lovell 2000). The stochastic frontier approach aims at estimating a cost or production frontier and to determine the distance of each farmer from the efficiency frontier. The empirical model is specified as

$$\ln VC = f(\boldsymbol{P}, \boldsymbol{Q}, \boldsymbol{Y}) + \nu + u \tag{11}$$

where $f(\cdot)$ is a function as specified by (9) and its arguments refer to prices, fixed inputs and output respectively. ν denotes a random component assumed to be distributed as $\nu \sim N(0, \sigma^2)$ and u is a systematic measure of cost efficiency for which $u \geq 0$ must hold. Negative values for u are prohibited since it is assumed that producers do not produce at negative costs. The interpretation of the efficiency measure u is simple: since $f(\cdot)$ represents the efficiency frontier large values of u imply large deviations from $f(\cdot)$ and therefore high levels of inefficiency. Since u cannot become negative it needs to be modeled using an asymmetric distribution. The likelihood function

constructed here is based on the exponential distribution, which is an asymmetric distribution and has achieved standard usage beside the half normal distribution.

A common approach is to estimate first the stochastic cost frontier to obtain estimates of u which are in a second step regressed on a set of independent variables not included in the previous model. The efficiency measure is modeled as

$$u = \alpha + \sum_{k=1}^{K} X_k \delta_k + \eta \tag{12}$$

where X consists of (i) the FHH dummy indicators and (ii) the set of interaction terms, where income from other sources than farming is interacted with the FHH dummies to account for household specific levels of p. Off-farm activities include income from wage labor, profits from business and remittances. The properties of the measure of inefficiency imply that negative parameter estimates for δ_k are associated with greater efficiency.

The results of the cost frontier with restrictions (10) imposed are given in table 9 in the appendix. All signs are standard and no unusual parameter estimates call for explanation. As the results of interest are related to the second stage regression, I focus on these coefficients only. The results from the regression of the inefficiency term on the set of FHH dummies and the interaction terms are presented in columns 2 and 3 of table 5. The parameter of *DJ Widow* is negative and significant at the 10 percent level indicating that the average state of the household after controlling for alternative sources of income corresponds to case 4. The negative sign implies that given land endowments and prices *DJ Widow* households are on average more efficient compared to MHH. The coefficients of all other household categories do not achieve any usual level of significance. *DJ Widow* households are therefore not only more productive than MHH but also compared to the remaining FHH categories as well. Regarding case 4, the negative sign implies that the probability that these households are threatened by shortfalls of income and thus need to achieve higher levels of productivity is higher as compared to the other household categories. Since neither *DF Widows* nor *DJ Temporary* households are affected by low bargaining power, case 4 is ruled out and thus these households must be assigned to case 1. For the other for FHH categories it is not possible to determine the level of bargaining power beforehand, making it impossible to draw unambiguous

conclusions. These household categories may either be equal to case 1 or case 4 households.

Table 5: Estimates of production efficiency of different FHH categories

	Two-Stage		Single-Stage	
	Parameter	t-value	Parameter	t-value
Dummy variables				
DJ Temporary	−0.009	−0.375	0.016	0.259
DF Temporary	−0.024	−1.304	−0.044	−0.978
DJ Widow	−0.031∗	−1.731	−0.094 ∗ ∗	−2.090
DF Widow	−0.001	−0.052	−0.033	−0.820
DJ Divorce	0.058	0.859	−0.034	0.708
DF Divorce	0.047	1.096	0.118	1.379
Single	−0.033	−0.486	0.147	−0.200
Polygamous	−0.023	−0.866	−0.043	−0.711
Interaction terms				
DJ Temporary	0.009	1.036	0.024	1.339
DF Temporary	0.017 ∗ ∗	3.769	0.034 ∗ ∗	2.930
DJ Widow	0.015 ∗ ∗	2.442	0.038 ∗ ∗	2.620
DF Widow	−0.004	−0.874	−0.002	0.202
DJ Divorce	−0.018	−0.797	−0.030	−0.520
DF Divorce	0.002	−0.180	−0.005	−0.183
Single	0.010	0.526	0.029	0.638
Polygamous	0.000	−0.047	−0.013	−0.788

** parameter significant at 5 percent level
* parameter significant at 10 percent level

The interaction term for *DF Temporary* is significant and positive indicating that the low decision making competence increases farm inefficiency as soon as income from other sources rises. This result suggests a transition of *DF Temporary* households from case 4 to case 2. The insignificant parameter for the dummy variable may thus be interpreted such that in the first stage *DF Temporary* households correspond to case 4 where the effects induced by p and θ neutralize each other, that is, the positive productivity effect emerging from low values of p is compensated by the negative efficiency impact that arises from low values of θ. *DJ Widow* households reveal a significantly positive parameter for the interaction term, too. Both cases are conform to the hypotheses that the negative impact of tenure insecurity on farming becomes increasingly apparent with rising p. However, tenure insecurity affects only households where women are left with low decision

Table 6: Estimates of production efficiency of single FHH indicator

	Two-Stage		Single Stage	
	Parameter	t-value	Parameter	t-value
Dummy variables				
FHH	−0.136	−1.415	−0.030	−1.222
Interaction terms				
FHH	0.007 ∗ ∗	3.023	0.019 ∗ ∗	3.116

** parameter significant at 5 percent level
* parameter significant at 10 percent level

making power or where they are threatened of losing their land, that is, only households facing low levels of θ exhibit increasing inefficiency with rising off-farm incomes. All other households just achieve the same levels of average efficiency that characterizes MHH.

The approach of regressing the relative inefficiency term on a set of dependent variables not contained in the previous stochastic frontier estimate has been criticized. First, as the estimates of u are obtained in a first stage and then regressed on further variables in a second step, the estimates of the second stage are inefficient. Secondly, an important condition under which this approach yields unbiased estimates is that the regressors contained in the first stage must be uncorrelated with the regressors of the second stage. If this condition is violated, the first stage estimators are biased. This condition is likely to be violated in the present setting as variables like land size are correlated with the different FHH categories (see table 3). However, biased estimates also yield biased estimates of the inefficiency terms. In order to assess the bias emerging from the correlation between first and second stage regressors, I substitute (12) for the inefficiency u measure in (11), that is, I include the dummies along with the interaction terms in the first stage and treat these as technological parameters. This is a standard practice that has been pursued by other authors in other contexts as well (see Kumbhakar and Lovell 2000). The estimates are given in columns 4 and 5 of tables 5. The coefficients from the direct estimation of the cost function reveal some

bias and inefficiency of the two-stage approach but basically confirm the results of the previous procedure. However, the parameter estimates of the significant coefficients more than double in absolute size and the dummy for *DJ Widows* becomes significant at the 5 percent level. The results therefore seem to be robust to different estimation approaches.

Given that the dependent variable is the logarithm of total variable costs, the parameters for the dummy variables can be interpreted as semielasticities. This measure gives the change of costs in percentage terms in response to a 1 unit change of the independent variable. Applying the semielasticity to the estimates reveals that, at given outputs, being a *DJ Widow* household reduces cost by 9.4 percent. On the other hand, the parameters for the interaction terms can be treated as elasticities, since off-farm income enters the estimations in logarithmic form. A doubling of income, that is, an increase by 100 percent increases farming costs by 3.4 percent for *DF Temporary* households and by 3.8 percent for *DJ Widows*. This number needs to be interpreted in terms of the very low level of off-farm incomes, where a doubling of earnings is feasible, but still does not imply a substantial increase of welfare.

The contrasting signs of the dummy and interaction terms of *DF Temporary* and *DJ Widow* households imply a turning point in productivity at which households 'switch' from greater to lower efficiency in the course of the transition from case 4 to case 2. The amount of log income per capita multiplied by the coefficient of the interaction term that equals the coefficient from the dummy variable in absolute size gives this turning point. For example, given the more reliable estimates of the latter approach, the estimate for this point is determined for *DJ Widows* by $0.094/0.038 = 2.47$ which equals 11.87 Kenyan shillings. The turning point is very low and *DJ Widow* households become immediately more inefficient compared to the average MHH as soon as any off-farm income becomes available. The same conclusion holds for *DF Temporary* households for whom the insignificant dummy implies a value of zero which suggests that the turning point is zero as well by resorting to the previous analysis. Column 3 in table 7 shows the share of households engaged in off-farm activities. For *DJ Widows* this share is particularly low compared to MHH but also with regard to the other FHH categories. Thus only a few of these households actually achieve the turning point. Although the share of *DF Temporary* is with 36.91 percent

Table 7: Labor supply and shares of income generating households

	Labor supply in hours per week and hectare	Share of households engaged in off-farm activities
MHH	17.50	45.00
FHH	17.80	36.02
DJ Temporary	13.67	24.02
DF Temporary	19.37	36.91
DJ Widow	18.85	21.95
DF Widow	15.91	34.81
DJ Divorce	N.O.	28.00
DF Divorce	N.O.	49.35
Single	N.O.†	40.74
Polygamous	9.71	36.80

†N.O. indicates not sufficient observations.

slightly higher, it is still low and thus only few households actually shift from one state into the other.

The results further suggest that FHH are not a homogeneous household category that can be simply aggregated to arrive at conclusions on productivity. Testing the equality of the parameters for the eight dummies does not reject the hypothesis that all coefficients are equal neither does a test for the equality of the interaction terms. However, testing whether the *DF Widow* and the *DJ Widow* interaction term have the same size yields a χ^1_2-value of 4.86 which rejects the null of equal coefficients. An illustration of the problems arising from the heterogeneity of parameters is illustrated through the inclusion of a single FHH household dummy plus an additional interaction term in the second stage regression. The result is shown in line 1 and 2 of column 1 in table 6. The single FHH dummy that subsumes all different categories under a single indicator exhibits a negative sign, but does not become significant. The interaction term, on the other hand, is positive and significant at the 5 percent level. Also, the interaction term of the single FHH category covers up the six categories that revealed insignificant coefficients and thus hides the heterogeneity of the eight different classes. Furthermore, the single indicator does not offer an explanation other than *ad hoc* justification of the results, as it does neither account for different levels of bargaining power nor decision making authority.

The results call for an investigation of the source of the different productivity levels among FHH. The theory predicts that labor supply should

systematically differ across households. Using the labor supply data provided in the WMS 3 weekly hours of labor supply per hectare of land are shown in table 7, while keeping in mind that these are likely to be subject to measurement error. The data show that the most productive household category *DJ Widow* also reveals almost the highest supply of household labor. Although this data must be interpreted with some caution, it is conform to the empirical results which established that *DJ Widow* are on average more productive than other household categories, if no off-farm income is available. Since, as discussed, also *DF Temporary* households are conform to case 4 when no other income but farming is available, the labor supply data also fits to these households, which exhibit the highest labor supply in the table. The labor supply data therefore further support the theory which predicts higher labor supply and greater levels of productivity among households located below their target income.

Table 8: Estimates of production efficiency of different FHH categories using dummy variables only

	Two-Stage		Single-Stage	
	Parameter	t-value	Parameter	t-value
Dummy variables				
DJ Temporary	0.022	0.140	0.052	0.971
DF Temporary	0.014	0.900	0.028	0.730
DJ Widow	−0.011	−0.695	−0.042	−1.047
DF Widow	−0.009	−0.654	−0.041	−1.179
DJ Divorce	0.029	0.511	0.075	0.529
DF Divorce	0.042	1.270	0.133	1.638
Single	−0.011	−0.207	0.033	0.250
Polygamous	−0.024	−1.092	−0.069	−1.353

** parameter significant at 5 percent level
* parameter significant at 10 percent level

Finally, I investigate the impact of introducing the interaction terms in the model and re-estimate the same models presented above, but without the interaction terms. The results, presented in table 8 are striking. None of the dummy variables turns out to be significant indicating that the different effects emerging from θ and p compensate each other. This finding emphasizes the necessity to control for the conditions under which FHH operate. Without the introduction of the interaction terms, the two household

categories *DJ Widow* and *DF Temporary* would appear equally efficient as all other categories. One would conclude, that tenure insecurity does not pose to be a problem, which is not the case referring to the results from the previous analysis.

6 Conclusions

In this paper I have investigated the regime dependency of the response of FHH farmers to tenure insecurity and low decision power. The results suggest the existence of two different states where households can transit from one state of high risk of falling short of income into another where income risks are less or not prevalent. These states, if not appropriately controlled for would otherwise yield biased results and lead to wrong conclusions. Depending on the conditions, FHH may seem to be equally productive compared with MHH and tenure insecurity would not appear to play a role in labor allocation decisions. Previous studies on this issue finding that FHH turn out to be even more productive (e.g. Moock 1976) do not offer an explanation for this finding and also seem to suggest that FHH fare better compared to MHH. However, the model developed in this paper shows that households supply more labor when facing income risks and thus allows for explaining higher levels of productivity of FHH. Furthermore, using this concept it is possible to reconcile the finding of higher levels of productivity among FHH with the often repeated result that FHH are actually less productive, through integrating the concepts of income risk and tenure insecurity. Judging from the empirical results, both risks seem to be credible and FHH respond to them. The theory and the results of the paper further reveal the relativity of the productivity concept. Even though, after controlling for land endowment and input prices, some *DJ Widow* households are on average more productive compared to the other household categories, this productivity is not an expression of large production outcomes but rather a result of people facing poverty which they want to escape.

A second important result that came up in this study is that FHH categories are significantly different from each other, such that, when FHH are joined into a single household category, any analysis of productivity in rural areas falls short of capturing the specific constraints each of these household categories is facing. The results show that tenure insecurity and the lacking

ability to decide on investments are visible in only a few categories, revealing an impact on productivity in two household categories only. The findings are consistent with the assumption that male influence or bargaining power appears to be a factor that determines household production decisions. It is interesting to note that even within seemingly similar categories like widows, divorced or temporary FHH there are significant differences. The findings presented here imply that a rethinking of the concept of FHH with regard to production and access to resources, but possibly also in the context of welfare, time use etc. would help to uncover structural discrimination and its sources.

The results point to the potential underestimation of the negative effects arising from tenure security when the FHH category specific constraints are not controlled for. This finding suggests that in previous studies the effect of tenure insecurity may turn out to be too low, which emphasizes the need and again raises the question for secure land right regimes for women and men. Only the granting of secure access to productive resources is a viable means to sustainably improve the lot of women in the long run. Insecure access to land has further implications as in rural areas it directly translates into the impossibility to obtain credits and to expand into further income generating activities. The finding that some FHH achieve higher production efficiency does not invalidate the necessity of targeted programs for women, but in view of the theory call for a refinement of the legal system and the status of women.

A Appendix 2.1

Table 9: Estimates of the cost function parameters

	Stochastic Frontier		Constrained OLS	
	Parameter	t-value	Parameter	t-value
lnland	−0.067	−0.455	−0.066	−0.444
lnhhlwage	0.444 ∗ ∗	4.614	0.458 ∗ ∗	4.713
lnwage	0.528 ∗ ∗	5.551	0.515 ∗ ∗	5.365
lntractor	0.028 ∗ ∗	5.111	0.027 ∗ ∗	4.878
pest	0.049	1.307	0.050	1.332
fert	−0.039	−1.286	−0.041	−1.361
prim	0.002	0.088	−0.007	−0.307
sec	0.050	1.535	0.036	1.093
extension	0.044	1.329	0.046	1.406
irrigate	0.044	0.756	0.035	0.602
manure	0.094 ∗ ∗	2.931	0.098 ∗ ∗	3.068
lnmaize	0.248 ∗ ∗	2.792	0.248 ∗ ∗	2.793
lnveggies	0.174 ∗ ∗	2.639	0.168 ∗ ∗	2.551
lncash	0.218	0.691	0.222	0.707
lab_land	−0.003	−0.184	−0.003	−0.218
lab_w	0.016	1.457	0.013	1.199
lab_t	−0.030 ∗ ∗	−4.210	−0.030 ∗ ∗	−4.235
lab_maize	−0.010	−1.081	−0.008	−0.915
lab_cash	−0.013	−0.393	−0.014	−0.426
lab_veg	−0.029 ∗ ∗	−4.367	−0.029 ∗ ∗	−4.381
land_w	0.007	0.309	0.006	0.245
land_maize	−0.004	−0.678	−0.004	−0.661
land_cash	−0.020	−1.188	−0.021	−1.295
land_veg	−0.002	−0.358	−0.001	−0.243
land_t	0.009	0.545	0.009	0.562
w_t	0.040 ∗ ∗	4.226	0.041 ∗ ∗	4.328
w_maize	−0.044 ∗ ∗	−3.267	−0.045 ∗ ∗	−3.350
w_cash	−0.019	−0.294	−0.021	−0.330
w_veg	−0.008	−0.797	−0.008	−0.746
t_maize	0.001	0.137	0.002	0.206
t_cash	−0.089 ∗ ∗	−3.338	−0.088 ∗ ∗	−3.322
t_veg	0.018 ∗ ∗	2.408	0.019 ∗ ∗	2.500
maize_cash	0.043 ∗ ∗	5.530	0.044 ∗ ∗	5.607
maize_veg	−0.048 ∗ ∗	−19.135	−0.049 ∗ ∗	−19.154
cash_veg	0.005	0.717	0.005	0.671

Table continues next page

—— Table continued ——

sqlnland	0.006	1.023	0.006	0.983
sqlnlabor	0.014	1.360	0.017	1.618
sqw	$-0.056**$	-3.425	$-0.055**$	-3.318
sqt	$-0.010*$	-1.807	$-0.011*$	-1.955
sqlnmaize	$0.062**$	27.784	$0.062**$	27.515
sqlncash	$0.059**$	3.723	$0.059**$	3.755
sqlnveggies	$0.036**$	18.786	$0.036**$	18.687
α	$3.406**$	11.454	$3.442**$	11.564

** parameter significant at 5 percent level
* parameter significant at 10 percent level

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