Liquidity constraints and farm household technical efficiency. Evidence from South Africa.

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Abstract

This paper provides an analysis of household technical efficiency using a sample of farm households in the KwaZulu Natal province of South Africa. The analysis has been conducted at household level and off farm activities has been considered as additional outputs of production in the non-parametric estimation of technical efficiency. This approach better captures the jointness between farm and non-farm activities induced by the presence of market imperfections and technical interdependencies. An important source of liquidity for South African households is the receipt of a pension. Its effect on household technical efficiency is identified exploiting the age eligibility criteria adopted by the South Africa Old Age Pension program. The results show that access to liquidity and income diversification have a positive effect on household technical efficiency suggesting that institutional reforms to improve access to labor and credit markets can allow a more efficient use of farm household resources.

Keywords: farm household technical efficiency, access to liquidity, income diversification, pensions.

JEL: O12, O13.

1 Introduction

Farm household efficiency is a multidimensional concept that has been widely analysed in the empirical literature and consists of two main components: technical and allocative efficiency. This papers focuses on farm household technical efficiency and adopts a household level approach that takes into account the role of non-farming activities. The analysis helps to understand farm households' behaviour and the constraints that prevent the optimal use of household resources. A large fraction of rural households in KwaZulu Natal province of South Africa has access to land for agricultural purposes. Nevertheless farming activities, remain a marginal source of income. Understanding the reasons underlying poor performances in agriculture is an important task to provide insights for the ongoing land reform and redistribution programs and to improve the role of agriculture in contributing to the livelihood of rural households.

A previous study done by Piesse et al. (1996) provides a first analysis of South African farms' technical efficiency that is, however, confined to a limited sample of households in the three homelands of KaNgwane, Lebowa and Venda. It is recognised in the literature that rural households engage in a wide range of activities in order to generate a livelihood. The standard analysis of technical efficiency is here extended to capture the linkages between farming and non-farming activities that characterised most of rural households. This paper follows the work of Chavas et al. (2005) who show that in the presence of market imperfections or when farming and non-farming technologies are joint, farm and off farm decisions are non - separable and a household level analysis of technical efficiency is more appropriate than a farm level analysis. This approach, initially introduced by Chavas and Alibert (1993), has been adopted more recently by Fletschner (2008), Fletschner and Zepeda (2002), Anriquez and Daidone (2008) and Fernandez-Cornejo (2007).

The impact of liquidity constraints on household behavior is analysed considering the pension transfer provided by the South Africa Old Age Pension Program to all women over age 60 and men over age 65. Through this analysis, this paper contributes to the current debate on the effects of the South African Old Age Pension Program on household behaviour. One of the controversies lies on whether the pension receipt induces an income or a liquidity effect. In the first case, the receipt of the pension reduces recipient and, possibly, other family members' labor supply. On the other hand, if the household is liquidity constraint, the pension receipt can have a positive effect on labor supply enabling farm investment and financing job searching also through migration. On one side Bertrand et al. (2003) argues that the pension transfer has a negative effect on labour supply of the prime age adults living with a pensioner, the impact differs according to the age and gender of the individuals. Ranchhod (2006) also finds a negative effect of the pension on the labour supply of the beneficiaries. On the other side, Klasen (2008) finds no effect of pension income on the reservation wage of the unemployed and Jensen (2004) finds no evidence that households reduce labor supply when they receive the pension. Moreover, Posel et al. (2006) and Ardington et al. (2009) questioned the findings in Bertrand et al. (2003) arguing that once migrants are included in the analysis the results change considerably. This study attempts to further address this issue by focusing on farm households that have the peculiar characteristic of being a supplier and an employer of labor at the same time. The relationship between pension and labour supply is analysed from a different perspective. In the empirical estimation of technical efficiency the number of adult family members are considered as inputs in the production of on and off farm outputs. In this context, a negative labor supply effect will imply a negative impact of the pension on technical efficiency since labor inputs are left unproductive. On the other hand, if households are liquidity constrained, access to the transfer is expected to improve household technical efficiency, for example, by enabling the use of more expensive and higher quality inputs and factors or by allowing households to overcome the entry barriers in the labor market.

In the empirical estimation, the liquidity effect is identified by exploiting the age eligibility criteria adopted by the South Africa Old Age Pension Program. Pension eligibility is used instead of actual pension receipt and several checks are conducted in order to examine the presence of potential confounding effects between the eligibility indicator and age trends or differences in background. Instrumental variable technique is also used to address the potential endogeneity of the income diversification index. The results show that access to liquidity and income diversification have a positive effect on household technical efficiency suggesting that institutional reforms to improve access to labor and credit markets can allow a more efficient use of farm household resources.

This paper begins with a discussion of the definition and measurement of technical efficiency. Section 2.1 provides theoretical support for the use of a household level analysis. This is followed by a discussion of the nonparametric technique adopted for the estimation of technical efficiency. Section 3 offers an overview of the data used and presents the results of the estimation of the technical efficiency scores. Section 4 describes the empirical strategy adopted for the analysis of the determinants of household efficiency and discusses the results. Finally section 5 concludes.

2 Farm household technical efficiency

The concept of technical efficiency is based on the identification of a production frontier that represents the maximal combination of outputs attainable given the available set of inputs. Farm households operating on the frontier are considered technical efficient while households located below the frontier are considered inefficient.

Some considerations are now required to conciliate the above theoretical considerations with the empirical possibilities. An adaptation of the concept of technical efficiency is required to meet practical methodologies and data availability. The aim of any empirical analysis of technical efficiency is to provide a measure that captures the relationship between the observed production and some ideal, or potential production (the frontier). In principle, if all the possible combinations of inputs and outputs of production are known, a measure of pure technical efficiency could be obtained and would be in line with the above theoretical formulation. However, not all input - output combinations are known, quality may not be observed and data are usually available only for a sample of productive units. Therefore two main issues arise. First, because it is not possible to observe the ideal or potential productive frontier, this concept needs to be adapted to what is observable and measurable. Departing from the underlying theoretical proposition that no units can exceed the ideal level of production, two main practices are conventionally adopted to obtain an estimate of the productive frontier: a) assuming a specific functional form for the relationship between inputs and outputs, b) considering the best performing units in the sample as forming the frontier. Second, the interpretation of inefficiency scores needs to be adapted to the availability of information on each farm in the sample. The assumption of homogenous inputs and outputs is necessary when their quality is not observed. Neglecting input and output varieties, unobservable characteristics contribute to the variation in the apparent (estimated) efficiency. Moreover, the use of aggregate product and input values raises some concerns that will be discussed in section 2.2.

In general, because the concept of technical efficiency needs to be adapted to accommodate empirical possibilities and the availability of data, cautions need to be taken in the interpretation of efficiency scores. Although they may not capture pure technical efficiency i.e. pure technical and engineering relationships, they provide a useful representation of the variation in the intensity and effort in the use of observed inputs across farm households (Carter, 1984). In the rest of the paper, I will refer to this modified concept of technical efficiency as observed technical efficiency. Besides these general considerations, additional issues arise in relation to the specific method of estimation adopted and will be discussed when the empirical methodology is described.

2.1 Technical efficiency at farm household level

Conventional analyses of technical efficiency at farm level have generally neglected the non-separability between farm household production and consumption decisions generated by market imperfections and identified by several papers (Bowlus and Sicular (2003), Carter and Yao (2002), Cafiero et al. (2004)). In this section a theoretical farm household model is presented to illustrate the consequences that market imperfections have on household behaviour.

A standard farm household model is extended to include a liquidity constraint and transactions costs in the labor market. The effective cost of hiring labor (H) is given by the market wage plus search and supervision costs and is defined as w_h. The effective off farm wage includes search and other transaction costs (w_o). The imperfections in the labor market are therefore translated into the following relation $w_o < w_h$. The farm household produces an output y_q given the technology $F(y_q, H, X, L_q)$ where X is the amount of farm inputs and L_q is the amount of family labor. At the moment, the implications of technical interdependencies between on and off farm technologies are ignored, these have been analysed in Chavas et al. (2005) and will be recalled next. The household maximises utility, subject to the budget constraint, the farm technology and a time constraint, where E represents the household endowment of time. Household utility is a function of a composite market good, c, consumption of own-produced products, c_q and leisure l. The market prices of non-factor inputs, outputs and consumption goods are indicated by p_x, p_q, p_c respectively.

Household decisions are subject to the availability of pre-harvesting cash. A simple way to incorporate this liquidity constraint is to consider that a fraction of commodities and factors is purchased before the harvesting. In particular, a fraction, α, of the costs of farm inputs and hired labour have to be incurred ahead of the harvest. During this period the household has access to a fraction of its annual off farm earnings, and to a certain amount of off-farm transfers S, that is a fraction of the total annual transfer received by the household, T.

$$\begin{aligned}
&\max_{y_q, X, H, L_q, c, c_q, l} U(c, c_q, l), \\
&s.t \quad F(y_q; X, H, L_q) = 0, \\
&\qquad p_c c \leq p_q(y_q - c_q) - p_x X - w_h H + w_o L_n + T, \\
&\qquad \alpha(p_x X + w_h H) \leq \alpha w_o L_n + S, \\
&\qquad l + L_n + L_q = E.
\end{aligned}$$

Substituting the time constraint into the previous two, the lagrangian for this problem is:

$$\begin{aligned}
L = {} & U(c, c_q, E - L) + \lambda[p_q(y_q - c_q) - p_x X - w_h H + w_o L_n + T - p_c c] \\
& + \phi F(y_q; X, H, L_q) + \eta[\alpha w_o L_n + S - \alpha(p_x X - w_h H)].
\end{aligned}$$

The first order conditions relevant for this analysis are reported below.

$$\begin{aligned}
y_q &: \phi \frac{\partial F}{\partial q} = -\lambda p_q, \\
H &: \phi \frac{\partial F}{\partial H} = \lambda w_h^*, \\
X &: \phi \frac{\partial F}{\partial X} = \lambda p_x^*, \\
L_q &: \phi \frac{\partial F}{\partial L} = \lambda w_o^*, \\
\phi &: F(y_q, y_n; X, H, L) = 0.
\end{aligned}$$

where $w_o^* = (1 + \alpha\eta/\lambda)w_o$, $w_h^* = (1 + \alpha\eta/\lambda)w_h$ and $p_x^* = (1 + \alpha\eta/\lambda)p_X$ represent the household specific shadow prices of labor and farm inputs. If inputs are not acquired ahead of the harvest, $\alpha = 0$, their price corresponds to the effective market price that incorporates transactions costs. On the other hand, pre-harvesting purchases of hired labor and farm inputs are constrained by the availability of liquidity. Their prices are marked up by the marginal utility of liquidity, η.

In order to analyse the conditions supporting the use of a household level analysis of technical efficiency I adopt a broad definition of jointness in production usually applied to multi-product agricultural production[1]. According to this definition, two activities can be characterised by a joint production function when an increase or a decrease in the supply of one output affects the supply of the other (Havlik et al., 2005), and can be represented by the following condition:

$$\Delta y_i / \Delta y_j \neq 0,$$

where Δy_i represents the change in output i. In line with this definition, farming and non-farming activities can be considered part of a joint production decision process when one of the following conditions occurs: a) family and hired labor are imperfect substitutes , b) the household is liquidity constrained and c) there are technical interdependencies between farming and non-farming activities. Below I analyse these three aspects with a focus on their relationship with the observed measure of technical efficiency. As anticipated, because not all inputs, outputs and their quality are observed, unobservable factors contribute to the variation in the estimated level of technical efficiency across households. The use of low quality inputs, for example, can result in technical inefficiencies although the timing and the method of production employed are optimal.

The imperfect substitutability between family and hired labor (point a) is usually induced by the presence of transaction costs in the labor market. Regarding this latter aspects, the presence of supervision and other transaction costs, give family labor specific features that distinguish it from hired labor. This is indicated by the difference between the family and hired labor shadow prices, w_o^* and w_h^*. In this context, family labor can be considered as a quasi - fixed allocable input in the short run since no perfect substitutes are available. The presence of fixed allocable inputs is considered a cause of jointness in standard multi-output agricultural production (Havlik et al., 2005). In general, the presence of multiple outputs competing for a limited amount of inputs implies that the production of one output reduces the availability of resources and has a negative effect on the production of

[1]There is an ongoing debate in the literature on the definition of joint production, in particular I refer to Lau (1972), Shumway et al. (1984), Moschini (1989) and Leathers (1991).

the other output. This argument applies to the allocation of family labor between on and off farm activities and implies the jointness between farm and non-farming activities. The second aspect (point b) is related to the presence of a binding liquidity constrained. Farming decisions are constrained by the availability of financial resources. In this case, off farm earnings can promote farm production by allowing the purchase of more and better quality farm inputs. Finally, jointness may be caused by the presence of technical interdependencies between on and off farm technologies (point c). This is the case when, for example, skills acquired off farm improve farm management (Chavas et al., 2005). These arguments suggest the use of a household level analysis of technical efficiency to capture the relationship between farm and off farm activities. In particular, while a farm level analysis is appropriate when none of the above conditions applies, a household level analysis does not require such assumptions and, at the same time, can capture the reciprocal relationships between farming and non-farming activities that characterise the livelihood of rural households.

In the remaining of this section I will analyse how, in the context of a non-separable farm household model, access to liquidity and income diversification affect household observed technical efficiency. Access to transfers, such as pensions, can produce alternative effects. First, in the presence of a binding liquidity constraint, the transfer can help ease the constraint and allow the purchase of new technological packages that can increase the amount of output produced and therefore the observed technical efficiency. The household, for example, might be able to purchase higher yielding seeds or adopt a more remunerative cropping mix and increase production (Carter, 1989). This effect can be represented by a reduction in the shadow price of inputs, p_x^*, due to a reduction in the marginal utility of liquidity, η. Moreover, access to liquidity may help farmers to better cope with adverse shocks and afford the costs of entering better quality and more remunerative jobs, such as the cost of equipments, rents and skill acquisition. Even when the transfer is not used for productive purposes, but for food consumption, it can induce a more intensive use of land and family labor if the improved nutritional levels of family members are translated into higher labor productivities. On the other hand, a negative impact can also be observed and is specific to the methodology adopted for the estimation of technical efficiency. Because in the estimation of technical efficiency, which will be described in the next section, I consider the overall number of family members rather than hours worked as inputs of production, labor supply effects can also be captured. Exogenous transfers can produce an income effect that reduces household labor supply. In this case, a negative effect of the transfer on technical efficiency is expected since labor inputs are left unproductive. Finally, if the pension receipt partly crowds out private transfers such as remittances, as analysed in Jensen (2004), the potential income and liquidity effects are neutralised.

A similar analysis can be conducted for the impact of off farm earnings on household technical efficiency. Non - farming activities can have a positive effect on technical efficiency mainly because: a) non-farm earnings can provide liquidity to the household and produce similar effects to those reported above, b) skills acquired off farm can generate positive knowledge spillovers improving farmers' managerial ability. On the other hand, a negative effect is expected when off farm opportunities subtract time for farm management therefore preventing the adoption of management-intensive innovations. Which effects prevail is an empirical question[2] and will be discussed in the next sections.

2.2 Measuring technical efficiency

Farm household technical efficiency is estimated using a non-parametric approach known as Data Envelopment Analysis (DEA). This method, first introduced by Charnes et al. (1978), does not impose any restriction on the underlying farm technology [3]. This methodology is suitable for the analysis conducted here mainly because of its adaptability to multiple inputs and outputs that can be quantified using different units of measurement and because it does not require the distinction between hours worked on and off farm that are not available in the survey. Because it is a deterministic approach, deviations from the frontier are all attributed to inefficiencies. For example, differences in environmental and weather conditions are not taken into considerations. However, as far as this study is concerned, the use of

[2] Goodwin and Mishra (2004) for example, using a farm level efficiency analysis finds that the involvement in off farm activities decreases farm efficiency for a sample of US farms. The analysis, however is not extended at household level. Fletschner and Zepeda (2002) find a positive effect of income diversification on allocative efficiency using data on rural farm households in eastern Paraguay.

[3] The statistical properties of the estimator have been analysed in Banker (1993) where its consistency is proved. However, since the estimates are obtained from a finite sample, they are sensitive to sampling variations. Simar and Wilson (1998) propose a bootstrapping technique to estimate confidence intervals for efficiency scores that reveal their sensitiveness to sample variation

data on the KwaZulu-Natal province only, restricts the potential variation in such aspects.

The farm household technology can be represented by the following technology set $F(y_q, y_n; X, H, L)$ such that X, H and L can produce the farm and non-farm outputs, y_q and y_n where L is total family labor $(L_q + L_n)$. Technical efficiency (TE) is intended as the distance of the household input/output bundle to the multi-input multi-output productive frontier constructed using the information on all the farm households in the sample. Given the presence of multi inputs and outputs, the empirical estimation of technical efficiency is based on the concept of output distance function:

$$TE = \min\{\phi : F(y_q/\phi, y_n/\phi; X, L) = 0\}.$$

Following the DEA approach, the output oriented productive frontier is computed as the larger upper bound set of all the possible input - output combinations[4]. The frontier, therefore, is composed by the best performing farm households in the sample[5]. The output oriented technical efficiency is based on obtaining an optimal set of weights from the maximisation of farm's ratio of all outputs and inputs given by $\mu'\mathbf{y}_i/\nu'\mathbf{z}_i$, where $\mathbf{y}_i$ and $\mathbf{z}_i$ the vectors of output and input respectively and μ, ν are the associated vector of weights for the N farms in the sample. This is subjected to all efficiency measures being lower than 1 and is done by solving the mathematical programming model reported below.

$$\begin{aligned} &\max_{\mu,\nu} \frac{\mu'\mathbf{y_i}}{\nu'\mathbf{x_i}} \\ &s.t \quad \frac{\mu'\mathbf{y_j}}{\nu'\mathbf{x_j}} \leq 1 \quad j = 1, 2 \ldots N, \\ &\qquad \mu, \nu \geq 0 \end{aligned}$$

Departing from this base specification an additional constraint, $\nu'\mathbf{x} = 1$, is included to ensure the existence of a unique solution to the model. The derived problem can be represented in its envelopment (dual) form where ϕ

[4] I adopted a output oriented analysis since most of the inputs considered, such as land and family labor cannot be easily increased or decreased in the short run according to production requirements.

[5] Because it is likely to be sensitive to outliers, I employ the method proposed by Wilson (1993) to eliminate the identified outliers.

is the scalar associated to the equality constraint and λ is the vector of dual variables associated to the inequality constraints.

$$
\begin{aligned}
&\max_{\phi,\lambda} \phi, \\
&s.t \quad -\phi' \mathbf{y_i} + \mathbf{Y}\lambda \geq 0, \\
&\qquad \mathbf{x_i} - \mathbf{X}\lambda \geq 0. \\
&\qquad \lambda \geq 0,
\end{aligned}
$$

where $\mathbf{X}$ and $\mathbf{Y}$ are the matrices of inputs and outputs of all farms in the sample. The measure of technical efficiency is given by $1/\phi$.

The model so far assumes constant return to scale and is appropriate if all farms operate at optimal scale. This assumption may not hold when farms are facing market imperfections or constraints on liquidity since they can cause the farm to not operate at optimal scale (Coelli et al., 2005).Therefore the estimation of the production possibility frontier is conducted using variable returns to scale by including the constraint $\mathbf{I1}'\lambda = \mathbf{1}$, where $\mathbf{I1}$ is a vector of ones.

3 Household technical efficiency in KwaZulu Natal

The analysis of technical efficiency has been conducted using the third wave (2004) of the KwaZulu-Natal Income Dynamic Survey (KIDS)[6]. The KIDS is a comprehensive household survey that includes information on household characteristics, expenditure, income and farming activities. A sample of 547 farm households has been used for the estimation of technical efficiency[7] .

[6]KIDS data have been collected thanks to following collaborating institutions: University of KwaZulu-Natal (UKZN), the University of Wisconsin-Madison and the International Food Policy Research Institute (IFPRI) However, in order to accommodate new areas of interest, the participating institutions have been broadened to include the London School of Hygiene and Tropical Medicine (LSHTM) and the Norwegian Institute of Urban and Regional Studies (NIBR). In addition to the resources provided by each of the collaborating institutions, the study was funded by the UK Department for International Development (DFID) through DSD, the National Research Foundation, the Norwegian Research Council, USAID and the Mellon Foundation.

[7]The initial sample of farm households, including all households conducting agricultural activities, have been reduced following the method proposed by Wilson (1993) in order to eliminate few outliers.

About 80% of farm households produce maize that is often grown together with other cereals, vegetables and fruits. About 60 % of the farms own some livestock and are engaged in animal husbandry. Farms are in general small and the average land size is of about 1.4 hectares. Farm households rely also on off farm earnings and about 53% are involved in casual or permanent off farm activities that constitute an important component of overall household income. Non-farming earnings, excluding income from pensions, other transfers and remittances, contribute to the 58% of total income. Only 15% of households employ hired labor and about 30% do not use fertilisers, sprays or purchased seeds. The survey do not provide specific information on the credit status of the household, however only 20% of the households have access to formal credit, in particular only 5% has received a loan from a bank or building society. This evidence supports the presence of limited access to credit facilities for the households.

Table 1: Descriptive statistics of variables used for efficiency estimation

	Obs	Mean	Std. Dev.	Min	Max
Outputs					
Maize (in kg)	326	17.46	56.72	0.02	625.00
Vegetables (value in RAND)	388	38.34	98.74	0.07	870.83
Fruits (value in RAND)	71	27.08	48.65	0.12	301.25
Others (value in RAND)	121	8.97	23.88	0.25	250.00
Income from animals (in RAND)	294	146.24	299.04	0.13	2710.42
Off farm income (in RAND)	298	2272.72	2593.80	20.00	13267.0
Inputs					
Male members (in adult equivalent)	518	2.24	1.37	0.10	9.40
Female members (in adult equivalent)	542	2.56	1.59	0.30	12.00
Land (hectares)	557	1.38	7.04	0.00	75.00
Hired labor (number of workers)	80	1.629	2.51	0.08	14.83
Livestock (Tropical livestock unit)	340	2.10	3.71	0.01	35.00
Cost of inputs (value in RAND)	386	37.15	71.00	0.25	1016.6

The estimation of technical efficiency employs 6 outputs and 6 inputs that are reported in Table 1. The total production of maize has been measured in kilograms while vegetables, fruits and others products have been aggregated using farm level prices when available and median prices at district level otherwise. An additional aggregate output includes the revenues from the sale of animals, meat and animal products such as eggs and milk. Finally, off farm income includes the earnings from regular and casual employment.

Other forms of non-agricultural self-employment have not been considered since data were not reliable. The set of inputs includes the number of male and female adults that have been computed using the equivalence scale proposed by Deere and de Janvry (1981)[8]. Land represents the total surface devoted to farming activities while hired labor is measured using the number of permanent and temporary workers employed on the farm. The cost of inputs includes the cost of seeds, fertilisers, sprays, ploughing and veterinary expenses. Finally livestock has been measured in tropical livestock unit (TLU) that is a standard procedure used to aggregate across different species[9]. It is worth noting that the aggregation of inputs and outputs into aggregate categories such as labor, capital and purchased inputs using farm level prices. This introduces an additional conceptual issue. Technical inefficiency measures can be confounded with allocative errors between individual inputs and outputs within aggregate categories (Ali and Byerlee, 1991).

Table 2: Technical efficiency by district

District	Obs	Technical efficiency	% Efficient
Ugu	61	0.35	14.75
Umgungundlovu	26	0.42	19.23
Uthukela	56	0.36	14.29
Umzinyathi	27	0.30	7.41
Amajuba	36	0.37	11.11
Zululand	69	0.26	5.80
Uthungulu	88	0.38	13.64
iLembe	17	0.39	17.65
Vhembe	43	0.46	16.28
eThekwini	82	0.39	16.87
Total	505	0.36	13.44

The summary results of the estimation of technical efficiency are reported in Table 2. Efficiency estimates are low, the average estimates of technical

[8]This procedure attributes a weight of 0 to members aged below 3, 0.1 to children aged between 3 and 5, 0.3 to members aged between 5 and 8 and over 75, 0.5 to those aged between 8 and 12 and between 65 and 75, 0.8 to those aged between 13 and 17 and between 59 and 65 and 1 to the remaining members aged between 17 and 59.

[9]Cattle correspond to 1 TLU while sheeps and goats correspond to 0.7 TLU.

efficiency are lower then those reported in Piesse et al. (1996). However, DEA estimates largely depend on the characteristics and size of the sample considered. Therefore, comparisons with other findings are not possible. Considering for example the Ugu district, the average farm household can possibly increase output by 65% without changing the bundle of inputs employed. Because this analysis considers also off farm activities together with conventional farm outputs, high inefficiencies could also signal the presence of barriers to non-farm employment. This will be discuss in the next section where the determinants of technical efficiency are explored.

4 Determinants of farm household technical efficiency

In the analysis of the determinants of technical efficiency, the efficiency estimates are regressed on a set of contextual factors usually considered in the literature such as human capital and other household and market characteristics. In contrast with the inputs and outputs variables considered in the estimation of technical efficiency, these factors are intended to capture differences in managerial abilities and access to factor markets that affect household decision making[10]. The variables considered are reported in Table 3 together with the descriptive statistics. Human capital endowments are represented by the age and education of the household head and by the ratio of skilled members over overall adult family members. The regressions

[10]There is an ongoing debate on the use of this two stage procedure that involves the estimation of technical efficiency scores, in the first step, and regressions to relate efficiency scores to contextual factors in the second. On one side, Simar and Wilson (2007) argue that efficiency scores are serially correlated and proposed a seven step double bootstrapping procedure to produce consistent estimates in the second stage. While this approach has been adopted in the literature, it has not received general consensus. McDonald (2009) argues that it is valid only under the proposed data generating process and not robust to reasonable departures from it. Moreover, Banker and Natarajan (2008) provide statistical foundation for the simple two-stage procedure. Their simulation results indicate that a two-stage DEA based approach performs better than a commonly adopted set of one-stage and two-stage parametric procedures. However, hypothesis testing is not discussed. Given the computational complexity of Simar and Wilson (2007) approach, the drawbacks identified by McDonald (2009) and the arguments proposed by Banker and Natarajan (2008), I opted for a simple two stage procedure that has also been extensively adopted in the literature.

also include a dummy variable indicating whether the household has the title deeds on the land. Finally the employment rate at municipality level is intended to partially capture the presence of transaction costs and the degree of development of the local labor market. The employment rate has been constructed using data from the 2001 South Africa population census on 10% of total population. All regressions include district dummies to control for variations in environmental conditions and soil quality.

Table 3: Descriptive statistics of variables used in the efficiency analysis

Variables	Obs	Mean	Std. Dev.	Min	Max
Access to labor market and liquidity					
Share off farm income	547	30.89	34.27	0	100
Household eligibility (HE)	547	0.39	0.49	0	1
Employment rate (municipality level)	547	42.96	13.32	20.86	73.68
Household characteristics					
Gender of household head (male)	547	0.51	0.59	0	1
Land title	547	0.28	0.45	0	1
Human capital					
Age of household head	547	54.6	14.07	18	96
Education of household head	547	5.48	4.82	0	20
Ratio of skilled adults	547	0.24	0.22	0	1

A particular focus is given to the role of credit market imperfections in limiting the capacity of households to produce at higher levels of technical efficiency. One of the main sources of liquidity is off farm income that plays an important role in household income formation. Therefore, the share of off farm earnings on overall household income is included as an additional explanatory variable. Another important source of liquidity considered in the analysis is the receipt of a pension. The Old Age Pension Program in South Africa provides an unconditional cash transfer to all women over age 60 and all men over age 65. The program has been found to be effective in reaching poor households in rural areas and constitutes the basis of credit facilities in local markets (Ardington et al., 2009). The transfer is expected to have a relevant impact on household behaviour[11] given its generosity. In

[11]Several studies have investigated the effects of the South African pension system on children health (Duflo, 2003), household structure (Edmonds et al. (2005), Maitra and Ray (2003)) labour supply (Bertrand et al., 2003; Posel et al., 2006; Ardington et al., 2009)

Table 4: Descriptive statistics on pension receipt and eligibility

Age groups	% receiving the pension	Age groups	% non receiving the pension
Male members			
50-55	1.61	65-70	41.67
55-60	2.13	70-75	19.23
60-65	12.00	over 75	20.00
over 65	72.86		
Female members			
45-50	1.35	60-65	22.64
50-55	3.80	65-70	15.25
55-60	4.17	over 70	5.95
over 60	86.54		
Households with an eligible member			39%
Households with an eligible man			11%
Households with an eligible woman			34%

Source: author's calculation from 2004 KIDS Survey

Case and Deaton (1998) the authors find that the transfer is about twice the median per capita income of an African household. The baseline model for the analysis of technical efficiency is the following:

$$TE_i = \alpha + \beta \mathbf{X} + \delta P_i + \gamma O_i + \epsilon_i,$$

where TE_i indicates the technical efficiency scores estimated using the DEA method, $\mathbf{X}$ is a vector of contextual variables described above, O_i represents the share of off farm earnings on total income and P_i indicates that there is a person receiving a pension in the household.

Because pension take-up could be an endogenous household decision it generates a potential source of endogeneity. Therefore, I consider pension eligibility rather than actual pension receipt. The current South Africa Old Age Pension program is the result of the extension to the black population of the white social pension system established during the apartheid. The means test applied to the pension does not exclude most of the African households. The monthly pre-means test transfer in 2004 is of 740 RAND. Individuals in the sample receive an average pension transfer of about 719 RAND that suggests that, in most cases, the means test is not effective. Moreover, because it is not based on family income but only on recipient

and education (Edmonds, 2006).

wealth there are no incentives to pre-pension arrangements. This implies that pension eligibility depends only on the age of the recipient rather than on past earnings or household composition. Household members are eligible at age 60 if female and 65 if male. About 40% of the households in the sample have a pensioner member. The take-up rate is around 87% for women and 73% for men as reported in Table 4. This ensures that the eligibility indicator is a good approximation of pension receipt. The estimated equation is therefore:

$$TE_i = \alpha + \beta \mathbf{X} + \delta HE_i + \gamma O_i + \epsilon_i,$$

were HE_i indicates the presence of an eligible member in the household. This eligibility indicator, however, could also capture age trends or differences in background that could intensify or vanish the actual effect of the pension. This study allows for differences in household technical efficiency with the age structure of the household by controlling for the age of the oldest man and woman in the household and for the presence of adult male and female members close to the eligibility age. This is done by including dummies indicating the presence of female and male members over age 50 and 55 and male members over 60[12]. Pensions in South Africa have been found to affect household composition. Edmonds et al. (2005), exploiting the age-discontinuity in the structure of the pension program, finds and increase in the number of children aged 0 - 5 and in the number of women aged 18 - 23 and a decrease in the number of women aged 30-39 associated with pension receipt. In this study, a higher number of children in the household, for example, could lead to a lower household technical efficiency since more time is needed for children rearing and could therefore offset the possible benefits of having a pensioner in the family. To control for household living arrangements due to pension receipt the regressions include variables representing household size by age categories.

Additionally, because pension take-up differs from pension eligibility and varies between men and women the effect of a pension receipt could be underestimated. To address this issue I also report the results obtained by instrumenting the variable indicating the presence of a pensioner $\widehat{PENS}_i$ using the number of eligible female and male members in the household as reported below:

$$TE_i = \alpha + \beta \mathbf{X} + \delta \widehat{PENS}_i + \gamma O_i + \epsilon_i.$$

[12]This strategy has also been used in Duflo (2003) and Edmonds (2006).

The model has been estimated using a standard linear regression model and a two stage least squares estimator. The choice of this estimator, in contrast with the wide use of tobit models for the analysis of the determinants of efficiency, is motivated by the fact that technical efficiency scores should not be considered as censored values since they are not supported by a latent model. These efficiency indexes are better described as the result of a normalisation process imposed to ensure an unique solution to the linear programming model in 1[13]. Efficiency scores are therefore better categorised as fractional data (McDonald, 2009). Hoff (2007), comparing tobit and linear regression results, finds that the latter is sufficient to represent second step DEA models. Moreover, Angrist (2001) suggests the use of linear models even in the presence of a limited dependent variable when the main goal is the identification of casual effects in contrast to structural parameters. In the instrumental variable estimation (last specification) a dummy variable indicating the presence of a pensioner in the household is instrumented using a two stage least squares procedure. The use of a probit or logit model in the first stage would lead to inconsistent results unless the first stage model is correctly specified (Wooldridge, 2001). On the other side, conventional two stage least squares models are consistent independently of the non-linearity of the first stage (Angrist, 2001). Therefore, I opted for the use of a standard two stage least squares estimator. Finally, because of the fractional nature of the technical efficiency variables, the variance of the error term depends on the limit of the dependent variable ($TE_i = 1$)[14] and therefore on the regressors (McDonald, 2009). This implies that the error term is heterosckedastic and White's standard errors need to be computed for valid hypothesis testing.

4.1 Results

The analysis of the determinants of household technical efficiency shows a positive effect of income diversification (Table 5). This result is robust throughout all the specifications. This effect can indicate a positive liquidity effect since earnings from off farm activities can help to relax the liquidity constraint and allow the household to undertake efficiency enhancement purchases or to overcome entry barriers in the labor market.

[13]The use of a tobit is also justified when the outcome is a corner solution that, however, is not the case when considering efficiency scores.

[14]No households scores zero in terms of technical efficiency.

Table 5: Analysis of household technical efficiency

	OLS			IV
	(1)	(2)	(3)	(4)
Share off farm income	0.002***	0.002***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Household eligibility	0.097*	0.096*	0.093*	0.131*
	(0.054)	(0.056)	(0.056)	(0.077)
Gender of household head (male)	0.007	0.034	0.071	0.073
	(0.032)	(0.042)	(0.046)	(0.045)
Age of household head	-0.003	-0.002	-0.003	-0.004
	(0.002)	(0.002)	(0.003)	(0.003)
Education of household head	0.002	0.002	0.001	0.001
	(0.004)	(0.004)	(0.004)	(0.004)
Ratio of skilled over adult members	0.089	0.076	0.048	0.043
	(0.090)	(0.090)	(0.093)	(0.091)
Title on land	0.04	0.039	0.054	0.059
	(0.037)	(0.036)	(0.037)	(0.036)
Employment rate (district level)	0.003**	0.003**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Adults dummies		Yes	Yes	Yes
Age of oldest members			Yes	Yes
District dummies	Yes	Yes	Yes	Yes
Observations	547	547	505	505

Robust standard errors in parenthesis. All regressions include a constant, household size by age categories (0-5, 6-14, 15-29, 30-49 and over 50) and indicators of access to water and electricity. *, ** and *** indicate significance at the 10%, 5%, and 1% level of significance

At the same time, it could also signal the presence of positive knowledge spillovers from off farm to farming activities. At this stage of the analysis it is not possible to establish that effect prevails. However, the positive sign on the pension eligibility coefficient confirms the presence of a positive liquidity effect. Because the estimates of household technical efficiency consider household members (in terms of adult equivalent) as inputs of production, in the presence of a non biding liquidity constraint, a positive income effect would induce the household to consume more leisure and reduce labor supply leading to a lower overall household technical efficiency. In the presence of a binding liquidity constrained, instead, access to liquidity can, for example, allow farmers to adopt new technology packages that can shift the production surface (Carter, 1989). Because differences in the quality of inputs contribute to the overall technical efficiency, the purchases of more costly high yielding seeds can shift the entire input-output relationship and lead to higher efficiency. Column 4 reports the results of the two stage least square estimation where the variable indicating the presence of a pensioner is instrumented using the number of eligible male and female members. The first stage regression, not reported here, is strong with a very large t statistics (above 80). The results reported in column 4 (Table 5) confirm the findings when differences between pension take-up and eligibility are taken into account. The effect of the pension receipt is larger than that previously found suggesting that the effect of the pension could have been underestimated due to the difference between pension eligibility and actual pension receipt. The results also show a positive effect of the employment rate at district level. This indicates that a better access to job opportunities can improve the efficiency of the households.

Although remittances may constitute an additional source of liquidity, they are excluded from this analysis. A potential omitted variable bias problem could arise because of a correlation between remittances and the receipt of the pension. If, for example, the pension receipt produces a crowding out effect on remittances, the coefficient of the pension eligibility variable would be downward biased. On the other hand, if the receipt of a pension facilitates migration, financing job searching, two possible effects are expected. If it does not result in an increase of remittances, then the omission of remittances from the analysis should not bias the results. If, instead, remittances do increase, the effect on technical efficiency is expected to be similar to that of the pension and can be interpreted as an indirect liquidity effect of the latter. Migrants sending remittances are equally distributed across households and 41% of them are in households with an eligible member. Therefore, the exclusion of remittances from the analysis, that are likely to be subject to a measurement error, does not significantly affect the interpretation of the results.

In the regressions presented so far the share of off farm income on total household income has been considered an exogenous regressor. However, labor allocation decisions can be simultaneous to household efficiency that can influence the selection into off farm activities. Moreover, because off farm income is also used to compute household technical efficiency estimates, a potential measurement error in reporting off farm earnings could lead to a spurious correlation between the two variables. I deal with this potential endogeneity problem using instrumental variables technique. In particular

Table 6: Additional checks

	IV	OLS	
	(1)	(2)	(3)
Share off farm income	0.004*		
	(0.002)		
Household eligibility	0.151*	0.142*	0.096*
	(0.078)	(0.084)	(0.056)
Gender of household head	0.027	0.118	0.070
	(0.078)	(0.085)	(0.046)
Age of household head	-0.004	-0.009**	-0.003
	(0.004)	(0.004)	(0.003)
Education of household head	0.006	-0.009	0.001
	(0.007)	(0.007)	(0.004)
Ratio of skilled members	-0.077	-0.033	0.041
	(0.139)	(0.167)	(0.093)
Title on land	0.066	0.093	0.049
	(0.053)	(0.063)	(0.037)
Employment rate (district level)	0.004*	0.004*	0.003**
	(0.002)	(0.002)	(0.001)
Second quartile			0.016
			(0.045)
Third quantile			0.08*
			(0.044)
Fourth quantile			0.182***
			(0.048)
Adults dummies	Yes	Yes	Yes
Age of oldest members	Yes	Yes	Yes
District dummies	Yes	Yes	Yes
Observations	193	235	505

Robust standard errors in parenthesis. All regressions include a constant, household size by age categories (0-5, 6-14, 15-29, 30-49 and over 50) and indicators of access to water and electricity. *, ** and *** indicate significance at the 10%, 5%, and 1% level of significance.

I exploit the information on the share of off farm income in 1998 for those households observed in both waves of the KIDS survey. Using this instrument, the sample size is notably reduced. The results are reported in the first column of Table 6 and confirm previous results. However, the potential presence of serial correlation in the error term challenges the validity of this instrument. Although statistically valid and relevant, past participation in off farm activities can, for example, be correlated with current managerial skills and still leave the problem unresolved. Unfortunately, no better instruments are available. When households participating in off farm activities are excluded from the analysis, the positive liquidity effect of the pension receipt is still evident confirming that the potential endogeneity of the income diversification indicator has not affected the other results (Table 6, second column). Because of self selection issues, however, these latter results are not used for further inference. Finally, in the last column of Table 6, the share of off farm income does not enter directly in the regression. Instead, dummies, indicating that quartile in terms of the distribution of the shares the household belongs to, are included. The results show that when the share of off farm income is above 35%, non-farming earnings have a positive effect on household technical efficiency.

Additional checks have been conduced to further address the concerns about the discrepancy between pension take-up and the eligibility criteria. One of the reasons explaining these divergences lies in the potential misreporting of a person age. It is possible that interviewees report their age, or the age of their family member as round decades. If this is the case, it could be particularly problematic since pension eligibility for women is determined at age 60. To analyse the influence of a potential measurement error on previous results I run the above sets of regressions excluding those households with women aged 60. The results are reported in the first column of Table 7 and confirm previous findings. The coefficient of the pension eligibility variable is higher indicating that the effect of the pension on household technical efficiency could have been underestimated because of a potential measurement error in the reported age of the women in the household. To provide additional support to previous results, the age-discontinuity in the pension program structure is recalled to further address the issues of possible confounding effects between pension receipt and age trends. In column 2, the effects of the presence of a member close to the eligibility age, meaning a man aged between 50 and 64 and a woman aged between 50 and 59, is compared to the effect of having an eligible member aged between 65 and 75 and a woman aged between 60 and 75 in the household. The results show a significant impact of those age groups above the eligibility age, while no effects is found for the presence of adult members below eligibility. Finally dummies variable indicating the presence of an woman in different age groups that are: 45-50, 50-55, 55-60, 60-65, 65-70 and over 70, are included in the regressions. The presence of elderly men in the household is not considered since there are very little male pension beneficiaries. Results show that the effect of an adult woman in the household is decreasing in her age. However a sharp increase in the size of the coefficient is observed for the 60-65 age group and for the others above eligibility. This non linearity in the age of the woman cannot be explained by an age effect and is, instead, in line with the receipt of a pension at age of 60.

Table 7: Additional checks (2)

	(1)	(2)	(3)
Share off farm income	0.002***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)
Household eligibility	0.117*		
	(0.060)		
Gender of household head	0.084*	-0.002	0.034
	(0.047)	(0.032)	(0.039)
Age of household head	-0.004	-0.001	-0.003
	(0.003)	(0.002)	(0.002)
Education of household head	0.001	0.003	0.002
	(0.004)	(0.004)	(0.004)
Ratio of skilled members	0.06	0.079	0.076
	(0.093)	(0.090)	(0.090)
Title on land	0.053	0.041	0.005
	(0.037)	(0.036)	(0.037)
Employment rate (district level)	0.003*	0.003**	0.003**
	(0.002)	(0.001)	(0.001)
Person above eligibility		0.084*	
		(0.045)	
Person below eligibility		0.018	
		(0.045)	
Woman age 45-50			0.120**
			(0.054)
Woman age 50-55			0.087
			(0.063)
Woman age 55-60			0.047
			(0.064)
Woman age 60-65			0.130*
			(0.076)
Woman age 65-70			0.120*
			(0.068)
Woman age 70 and over			0.133**
			(0.072)
Adults dummies	Yes		
Age of oldest members	Yes		
District dummies	Yes	Yes	Yes
Observations	494	547	547

Robust standard errors in parenthesis. All regressions include a constant, household size by age categories (0-5, 6-14, 15-29, 30-49 and over 50) and indicators of access to water and electricity. *, ** and *** indicate significance at the 10%, 5%, and 1% level of significance

5 Conclusions

This paper provides an analysis of farm household technical efficiency using a sample of 547 farm households in the KwaZulu Natal province of South Africa. The study has been conducted at household level and off farm activities has been considered as additional outputs of production. This is motivated by the presence of market imperfections and technical interdependencies between farm and off farm activities. Household strategies to deal with market imperfections, such as the lack of credit and the presence of transaction costs, are captured in the household level analysis and contribute to a more comprehensive estimation of technical efficiency. The analysis has revealed the presence of large inefficiencies. Income diversification is found to increase household technical efficiency. Although it is not possible to establish a prevailing explanation, this effect can partly be attributed to a liquidity effect. The positive effect of the receipt of a pension from the Old Age Pension Program, in fact, confirms the presence of a binding liquidity constraint. Access to liquidity can help ease the liquidity constraint enabling farmers to undertake efficiency enhancement investment and overcome entry barriers to the labor market. These results suggest that institutional reforms to improve the access to the labor and credit market in the KwaZulu Natal province can allow a more efficient use of farm household resources.

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