Pension Transfers and farm household technical efficiency: evidence from South Africa

Article

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Abstract

This article provides an analysis of the effects of the old age pension on household technical efficiency using a sample of farm households in the KwaZulu-Natal province. The analysis is conducted at household-level and off-farm activities have 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 generated by the presence of market imperfections and technical interdependencies. The effect of the pension on household technical efficiency is identified exploiting the age eligibility criteria adopted by the South Africa Old Age Pension program. The results show a positive effect of the pension on household technical efficiency and suggests that, in rural areas, this large cash transfer can improve the ability of agricultural households to efficiently exploit their resources.

Keywords: farm household technical efficiency, pensions, South Africa.

JEL: O12, O13.

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 articles 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 the KwaZulu-Natal province of South Africa has access to land for agricultural purposes and engages in a wide range of farming and non-farming activities in order to generate a livelihood. Multiple livelihood strategies characterise rural households in South Africa and are determined by the opportunities and the constrained faced by the households (May, 2000). The majority of the poor in South Africa are found in rural areas and an increasing effort is devoted to the design and implementation of policies for rural development (Leibbrandt et al., 2006). Understanding the reasons underlying poor performance in rural areas is important to provide insights for the ongoing land reform programs and to improve the role that government policies and rural markets play 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. The standard analysis of technical efficiency is here extended to capture the linkages between farming and non-farming activities that characterise the majority of rural households. This article 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). This article provides a discussion of the implications of the measurement of technical efficiency and analyses the theoretical and empirical linkages between household technical efficiency and access to liquidity that have been scarcely explored in the literature.

The analysis focuses on the impact of the pension provided by the South Africa Old Age Pension Program on household technical efficiency. The effect is identified exploiting the characteristics of the program that provides a pension to all women over age 60 and men over age 65. Pension eligibility is used instead of actual pension receipt and several specifications are proposed in order to examine the presence of potential confounding effects between the eligibility indicator and age trends or differences in background.

Through this analysis, this article contributes to the current debate on the effects of the South African Old Age Pension Program on household behaviour. 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 and Woolard (2009) finds no effect of pension income on the reservation wage of the unemployed and Jensen (2004) finds no evidence that households reduce labour 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 contributes to this literature by providing an analysis of the impact of the pension on farm household technical efficiency. The farm household is a more complex unit of analysis since it involves both the supply and the purchase of labour. Although the empirical analysis cannot disentangle the channels through which the pension affects household technical efficiency, its net effect is positive and robust to several specifications suggesting that this large cash transfer can improve the ability of agricultural households to efficiently use their resources.

This article begins with a discussion of the definition and measurement of technical efficiency that is followed by a description of the theoretical arguments in support of the use of a household-level analysis of technical efficiency. I then discuss the linkages between the pension and household technical efficiency. The article continues with a discussion of the non-parametric technique adopted for the estimation of technical efficiency and an overview of the data. A description of the estimates of technical efficiency is followed by the empirical strategy adopted for the analysis of the determinants of household efficiency. The results are discussed and a set of robustness checks are conducted in order to examine the presence of potential confounding effects. Finally I present the conclusions.

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. Households operating on the frontier are considered technically efficient while those located below the frontier are considered inefficient. 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 production (the frontier). In principle, if all the possible combinations of inputs and outputs are known, a measure of pure technical efficiency could be obtained and would be in line with the above theoretical definition. 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 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: 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 household in the sample. The assumption of homogenous inputs and outputs is necessary when their quality is not observed. When neglecting input and output varieties, unobservable characteristics contribute to the variation in the observed (estimated) efficiency. Moreover, the use of aggregate product and input values raises some concerns that will be discussed next.

In general, because the concept of technical efficiency needs to be adapted to accommodate empirical possibilities and the availability of data, caution needs to be used in the interpretation of efficiency scores. Although they may not capture pure technical efficiency they provide a useful representation of the variation in the intensity and effort in the use of observed inputs across households (Carter, 1984). In the rest of the article, I will refer to this modified concept of technical efficiency as observed technical efficiency.

Technical efficiency at household-level

Conventional analyses of technical efficiency at farm level have generally neglected the linkages between farm and non-farm activities generated by technical interdependencies and market imperfections. As suggested by Chavas et al. (2005) the use of a household-level analysis of technical efficiency relies on the argument that on and off-farm activities are jointly produced.

Originally, the definition of joint production applied to multi-product firms refers to multiple outputs that cannot be produced separately, but are joined by the use of common non-allocable or public inputs (c1). Public inputs, once acquired to produce one output, are available costlessly for the production of other outputs (Baumol et al., 1982). Common examples are wool and mutton from sheep or wheat and straw. A second commonly cited cause of joint production is the presence of technical interdependences (c2), for example, when the pesticide used in a field affects the yields of the nearby field. These conditions are still regarded as primary causes of jointness. However, several authors (Shumway et al. (1984), Moschini (1989) and Leathers (1991)) consider the presence of multiple outputs competing for an allocable input that is fixed at the productive unit level (c3) as an additional source of jointness in production.

I will here follow Lau (1972) to provide a formal definition of joint production that will be related to the above mentioned causes of jointness. According to Lau (1972) a production function $F(y_1, y_2; x, z) = 0$ with two outputs, y_1 and y_2, and two inputs, x and z, is said to be non-joint in inputs[1] if there exist individual production functions $y_1 = f_1(x_1, z_1)$ and $y_2 = f_2(x_2, z_2)$ such that $F(y_1, y_1; x, z) = 0$ if and only if $x_1 + x_2 = x$ and $z_1 + z_2 = z$. That is to say that separate production functions can be obtained for each of the products and no inputs simultaneously contribute to the production of the two goods (Leathers, 1991). The above definition provides a mathematical representation of joint production but is not easily testable, therefore alternative behavioural propositions are also provided in Lau (1972). A necessary and sufficient condition for non-jointness in inputs is for the profit function, Π, to be additively separable in outputs. The maximised profit has the following property:

$$\frac{\partial \Pi^2}{\partial p_i \partial p_j} = \frac{\partial y_i^*}{\partial p_j} = 0, \quad i \neq j. \tag{1}$$

where y_i^* and p_i are the optimal level of output and the price of good i. According to equation 1, two outputs are attained from a non-joint production process if the supply of one good is not affected by changes in the price of the other product. While it is possible to notice that the above condition is violated in the presence of non-allocable inputs (c1) and technical interdependencies (c2) within a multiple output production process, a further step must be taken in order to explore how the presence of fixed allocable inputs (c3) can lead to jointness in production. Following Shumway et al. (1984), when a constraint on the total amount of inputs available is introduced ($\bar{z} = z_1 + z_2$)

the profit maximisation problem becomes:

$$\max_{x_i, z_i, \lambda} \Pi = \sum_i p_i f_i(x_i, z_i) - w x_i$$
$$s.t. \quad z_1 + z_2 = \bar{z},$$

The solution of this problem gives the optimal output supplies, $y_i^*(w, p_1, p_2, \bar{z})$ and $y_2^*(w, p_1, p_2, \bar{z})$. It is possible to notice that equation 1 is violated since the supply of one output is not independent of changes in the price of the other output.

The above definition can be applied to farm and non-farm activities. In particular, three conditions can possibly lead to the jointness between farm and non-farm production. The first refers to the presence of technical interdependencies and non-allocatable inputs within farming and non farming technologies that usually emerged when skills acquired off-farm improve farm management (Chavas et al., 2005). Ravallion (2003) points out the importance of externalities for rural development given the fact that most rural households engage in multiple activities. By engaging in off-farm activities, for example, farmers can learn about new techniques of production (Feder and Slade (1985), Foster and Rosenzweig (1995)), bookkeeping and finance management. Moreover some public inputs can be shared between farm and non-farm activities, for example, the housing infrastructure, food provision and equipments such as vehicles and other tools. The second condition refers to the imperfect substitutability between family and hired labour that is usually induced by the presence of transaction costs in the labour market. In this context, family labour can be considered as a quasi - fixed allocable input in the short run since no perfect substitutes are available. 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 the other output. Finally, in the presence of a binding liquidity constraint, farming decisions are constrained by the availability of financial resources and off-farm earnings can promote farm production by relaxing the on farm liquidity constraint. In general, while a farm production function can be entirely separated from the non-farm production function when none of the above conditions applies, a joint household-level analysis does not require such assumptions. In practice, this refers to the ability of quantifying the separate amount of inputs used for farm and non-farm activities. The difficulty of obtaining data on activity specific inputs partly arises from the joint nature of the two production processes as described above. Using standard surveys, for example, externalities between on and non-farm activities cannot be measured. Moreover, inputs are not usually recorded with sufficient detail (distinction between hours worked on and off-farm) and, because their allocation is affected by seasonality, often, only the total quantities available at household-level can be observed. Therefore, both the inherent jointness between farm and non-farm activities and the data limitations lead the use of a household-level analysis of technical efficiency.

In the remaining of this section I will analyse how access to a pension transfer can affect household technical efficiency. The discussion begins with a theoretical analysis of the linkages between liquidity constraints and technical efficiency. From a theoretical perspective, when considering pure technical efficiency, the relationship between liquidity and technical efficiency is complex. On one side, the presence of a liquidity constraint can improve technical efficiency since households are less likely to waste their resources. Conversely, a liquidity constraint may exacerbate the ability to access the labour and good markets and to purchase and apply inputs on time, reducing the overall household technical efficiency. At the same time, a relaxation of the liquidity constraint can allow the acquisition of better quality inputs. If inputs are correctly measured and differences in quality are taken into account, this would correspond to a reduction in lower quality inputs, namely a change in the proportion of inputs used. As reported in Farrell (1957), it is not possible to predict what will happen to technical efficiency when the proportions of inputs or outputs are changed.

A similar analysis can be conducted for the allocation of labour on and off-farm in the context of a household level measure of technical efficiency. Considering a farm household, which can be both a supplier and a purchaser of labour, the overall amount of labour employed is the sum of family labour on and off-farm and of hired labour. A pension transfer can produce alternative effects. In a standard farm household model, a liquidity constrain reduces the purchases of inputs, including hired labour, and induces the household to seek off-farm opportunities (de Janvry et al., 1992). The receipt of a pension, if used for productive purposes, is likely to induce an increase in the overall labour input or a relocation of family labour toward the activity in which the investments occurred. On the other hand, if the household is not liquidity constrained, the pension can produce an income effect, inducing the household to consume more leisure with unknown consequences on how efficiently the rest of the time and resources are employed. The reduction in family labour can result in either an overall reduction of the labour input, or, if family labour is substituted by hired labour, the overall labour input at farm household level could remain unchanged. In general, the transfer can induce a change in input proportions; its effect on household technical efficiency is ambiguous and the overall effect needs to be assessed empirically.

The linkages between the pension and technical efficiency become even more complex in the empirical analysis and are rooted in the methodology and the data adopted in the estimation of technical efficiency. As anticipated, because the production frontier is not observed and a measure of technical efficiency is obtained using the available information on inputs and outputs, where their quality is usually not 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 and there are no wastes. Estimates of technical efficiency, therefore, reflects the quality of inputs and outputs as well as the efficiency of their management

(Farrell, 1957). Access to the pension can, for example, allow the household to afford the costs of entering better quality and more remunerative jobs, through the acquisition of equipments and skills. If quality differences are not taken into account, households with better quality outputs are given a relative higher efficiency score (Farrell, 1957). Similarly, the purchase of better quality inputs can result in higher technical efficiencies. Moreover, even when the transfer is used for food consumption, the unobserved improved nutritional levels, if translated into higher productivities, can increase household technical efficiency. Therefore, if the pension contributes to improve the average unobserved quality of the inputs and outputs chosen, it is likely to result in an increase in household technical efficiency.

On the other hand, when input and output proportions are also affected, the impact of the pension on technical efficiency is ambiguous, as anticipated above, and the effects cannot be disentangled. It is, however, worth noting that the data used in this analysis do not allow for the distinction between leisure time and on and off-farm labour, and the overall number of family members is used to measure family labour[2]. Therefore, an income effect that reduces family labour supply would not be translated into a reduction of the family labour input but appears as if family labour is left unproductive. In general, it is not possible to disentangle the channels through which the pension transfer affects technical efficiency. Nevertheless, the empirical analysis will provide an estimate of the net effect of the pension on household technical efficiency that is useful to understand the role of this large cash transfer in allowing the household to efficiently exploit their resources.

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 is not available in the survey. Because it is a deterministic approach, deviations from the frontier are all attributed to inefficiencies and differences in environmental and weather conditions, for example, are not taken into consideration. However, as far as this study is concerned, the use of 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 labour. 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. The output oriented technical efficiency is represented below in its envelopment (dual) form:

$$\begin{aligned} &\max_{\phi,\lambda} \phi, \\ &s.t \quad -\phi' \mathbf{y_i} + \mathbf{Y}\lambda \geq 0, \\ &\quad\quad \mathbf{x_i} - \mathbf{X}\lambda \geq 0, \\ &\quad\quad \lambda \geq 0, \quad \mathbf{I1}'\lambda = \mathbf{1}. \end{aligned} \tag{2}$$

where $\mathbf{X}$ and $\mathbf{Y}$ are the matrices of inputs and outputs of all households in the sample. The elements of the vector λ_i are non-zero in correspondence to those households that form part of the relevant section of the frontier. The measure of technical efficiency is given by $1/\phi_i$ and the constraint $\mathbf{I1}'\lambda = \mathbf{1}$ allows for variable returns to scale.

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)[5]. Previous surveys are not considered since the sample size would be significantly reduced. The KIDS is a comprehensive household survey that includes information on household characteristics, expenditure, income and farming activities. A sample of 549 farm households has been used for the estimation of technical efficiency[6].

The sample includes only African households; they represent 85% of the population of the KwaZulu-Natal province while Indians represent 12% and White and Coloured only 3%. Most of rural KwaZulu-Natal was part of the former KwaZulu homeland, one of the ten ethnically based reserves constituted in 1913 with the Native Land Act in order to segregate the African population. The homelands were characterised by low quality land and, after the 80's, became increasingly overcrowded. The land was allocated by the local authorities and the increasing population density in these areas led to increasing pressure on the available land for farming purposes. Although land reforms have been implemented since 1997, no households in the sample have been involved in the restitution and distribution programmes. Farms, therefore, are in general small, the average land size is of about 1.4 hectares and the renting and selling of land is limited. Given the low productivity of the land, most of the households engage in off-farm activities to provide a source of living; about 53% of the households in the sample 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. However, given the high unemployment rate, in particular among unskilled workers, reliance on the labour market may not be sufficient to guarantee a livelihood. Multiple livelihoods are a characteristic of rural households in South Africa and have been extensively analysed in the literature (Lipton et al., 1996). Given the peculiarities of the context under consideration, the results obtained from this analysis, might not be generalised to the larger population of South Africa or to other rural contexts. Nevertheless, they contribute to the understanding of rural livelihoods in a context where land size is a critical constraint and off-farm opportunities, although limited, constitute for many households the one way out of poverty.

The estimation of technical efficiency employs 6 outputs and 6 inputs that are reported in table 1. About 80% of farm households in the sample 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. Only 15% of households employ hired labour 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. The total production of maize has been measured in kilograms while vegetables, fruits and others products have been aggregated using median prices at district level. 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 and other forms of non-agricultural self-employment. 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)[7]. Land represents the total surface devoted to farming activities while hired labour 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[8]. It is worth noting that the aggregation of inputs and outputs into aggregate categories introduces an additional conceptual issue since technical inefficiency measures can be confounded with allocative errors between individual inputs and outputs within aggregate categories (Ali and Byerlee, 1991).

The summary results of the estimation of technical efficiency are reported in table 2. The average efficiency estimates are low although with large variations within districts. Considering for example the Ugu district, the average farm household can possibly increase output by 58% 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[9].

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 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 labour market. The employment rate has been constructed using data from the 2001 South Africa population census on 10% of total population. All regressions include council dummies to control for variations in environmental conditions and soil quality.

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 Case and Deaton (1998) the authors find that the transfer is about twice the median per capita income of an African household. Because pension take-up could be an endogenous household decision, 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 which suggests that, in most cases, the means test is not effective. Moreover, because it is not based on family income but only on the recipient wealth, there are no incentives to pre-pension arrangements and pension eligibility depends only on the age of the recipient rather than on past earnings or household composition. 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 the following:

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

where TE_i indicates the technical efficiency scores estimated using the DEA method, $\mathbf{X}$ is a vector of contextual variables described above and HE_i indicates the presence of an eligible member in the household. The presence of the more lucrative off-farm opportunities, could potentially drive the results; the variable O_i represents the share of off-farm earnings on total income and is intended to capture the degree of income diversification. Because the pension eligibility indicator could also capture age trends or differences in background, 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.

The model has been estimated using OLS. 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 2[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. 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.

Results

The analysis of the determinants of household technical efficiency shows a positive net effect of the pension eligibility variable (table 5). This result is robust throughout all the specifications. Having a pension eligible person in the household causes an increase in technical efficiency that ranges between 0.10 and 0.11 units. This effect is relevant if compared to the fact that 25% of the households report a technical efficiency score lower than 0.10. Column 2 and 3 controls for the presence of adults in difference age categories and for the age of the oldest female and male members of the households. Column 4 reports Tobit estimates and shows not significant differences with previous OLS estimates.

The results also show a positive effect of the employment rate at district level, although not significant in all specifications, indicating that the presence of barriers to off-farm employment reduces household technical efficiency. There is also a significant relationship between technical efficiency and the gender of the household head. Being in a male-headed household has a positive effect on technical efficiency. Remittances may constitute an additional source of liquidity and about 34% of the households in the sample have a migrant member. Their inclusion in the specification reported in column 5 does not significantly affect the results. Their coefficient is positive but not significant and is likely to be affected by the presence of measurement errors and by the potential endogeneity of the household migration strategy. In particular, if households receiving remittances are relatively more disadvantaged and with lower technical efficiencies, the effect of remittances is underestimated.

The results reported in column 6 excludes households participating in off-farm activities. While previous results were not informative of the effect of the pension on farm efficiency, since the household-level measure of technical efficiency considered both on and off-farm activities, this latter specification shows the positive net effect of the pension on farm technical efficiency. This measure of technical efficiency is not influenced by the presence of the more lucrative off-farm opportunities. The presence of a pensioner in the household increases farm technical efficiency by 0.17 units. This effect is large given the fact that about 40% of the households not engaged in off-farm activities have a technical efficiency score lower than 0.17. These results, however, might be affected by self-selection biases. Therefore, they should be interpreted with caution.

The results reported so far shows a positive effect of the share of off-farm income over total household income on technical efficiency. This effect could indicate a positive liquidity effect similar to that of the pension since off farm earnings can help ease the liquidity constraint. At the same time, it could also signal the presence of positive knowledge spillovers from off-farm to farming activities. Nevertheless variations in output proportions driven by the presence of the more lucrative off-farm opportunities could also contribute to this result. In the regressions presented so far the income diversification variable has been considered an exogenous regressor. However, labour 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 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 notably reduces. The results are reported in the first column of table 6 and confirm the previous results. The potential presence of serial correlation in the error term could, however, challenge 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. However when the share of off-farm income is excluded from the analysis (column 2, table 6), the results are almost unchanged confirming that the potential endogeneity of the income diversification indicator does not affect the other estimates.

Additional checks have been conducted to address the concerns about the discrepancy between pension take-up and eligibility. One of the reasons explaining these divergences lies in the potential misreporting of age. It is possible that interviewees report their age, or the age of their family members in rounded decades. If this is the case, it could be particularly problematic since pension eligibility for women starts 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 due to a 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 household member close to the age of eligibility, namely a man aged between 50 and 64 or a woman aged between 50 and 59, is compared to the effect of having an eligible man aged between 65 and 75 and a woman aged between 60 and 75 in the household. The same exercise is conducted for the sub-sample of households that are not engaged in off-farm activities (column 4). The results show a significant impact of those members above the eligibility age, while no effect is found for the presence of adult members below eligibility. Finally, dummy variables indicating the presence of a woman in different age groups - 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 few male pension beneficiaries. The results reported in column 3 show that the effect of an adult woman in the household decreases with 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 the eligibility age. This non-linearity in the age of the woman cannot be explained by an age effect and is, instead, in line with the fact that a woman become eligible for the pension at age 60. Similarly, when the same specification is applied to households not involved in off-farm activities (column 5), only the coefficients of the age categories above eligibility are positive and significant indicating positive effects on farm efficiency. These latter results should again be interpreted with the caveat of possible self-selection.

The results show the positive effect of the pension on household technical efficiency. This effect is likely to be the result of a combination of factors. On one side, the transfer can help to ease a liquidity constraint enabling the households to apply inputs on time, access more remunerative jobs and acquire better quality inputs or improved technologies. On the other side, changes in input and output proportions could also be influencing the results. The comparison of farm and off-farm productivities can help to further explore the nature of this effect. Considering the average ratio of income from crops to the cost of non-labor agricultural inputs, households with at least one pensioner show a higher output to input ratio (15:1) than other households (13:1). Although there could be systematic differences in the two groups that are not controlled for, the higher productivity in agriculture could be partly explained by differences in the quality of the inputs and outputs and the technology adopted. This is in line with the findings in Carter and May

(1999) where the authors identify the presence of financial constraints that limits the ability of the farm households to effectively use productive assets and endowments. Similarly Fenwick and Lyne (1999) observe that the development and growth of small-scale agriculture in the KwaZulu-Natal province appears to be constrained primarily by liquidity levels. I also consider the ratio of labor income to the number of household members employed off-farm. Similarly, households with at least one pensioner have a higher ratio (4300 RAND per worker) than other households (3700 RAND per worker). Although the two groups could be highly heterogeneous under many aspects, these statistics suggest that access to the pension is correlated with higher off-farm productivity. This can be explained by the ability to access better quality jobs and to engage in more risky and remunerative off-farm activities. The effect of the pension, therefore, can be partly explained by higher on and off-farm productivities that are likely to reflect differences in the quality of both inputs and outputs.

Conclusions

This article provides an analysis of farm household technical efficiency using a sample of 549 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. The receipt of a pension from the Old Age Pension Program has a positive and relevant effect on household and farm technical efficiency. The results are robust throughout several specifications intended to deal with the presence of potential confounding effects. There is no prevailing explanation for the positive effect of the pension on household technical efficiency since liquidity effects are combined with quality effects and with those derived from efficiency-enhancing changes in input and output proportions. Nevertheless further analyses indicate that the pension allow the household to improve its on and off-farm productivities. The pension transfer therefore improves the ability of farm households to efficiently employ their resources and suggest that institutional reforms to improve the access to credit markets and government transfers can be beneficial for farm households in rural KwaZulu-Natal.

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Notes

[1]See Lau (1972) for the definition of jointness in outputs.

[2] Farrell (1957) discusses the implications of measuring labour in man-hours versus number of men employed.

[3] The statistical properties of the estimator have been analysed in Banker (1993) where its consistency is proved. The most common alternative approach, the stochastic frontier analysis, cannot easily deal with multiple outputs other than using an output aggregator. Moreover, the presence of zero-valued inputs is troublesome when using the most common functional forms that require logarithmic transformations. An alternative way to handle multiple inputs and outputs is the use of stochastic input or output distance functions (Kumbhakar,2000). These methods, however, require the use of logarithmic transformations that are not suitable for our analysis since most of the input and output variables have zero entries and the use of arbitrary measures, such as replacing zeros with very small numbers, would be necessary and questionable.

[4] I adopted an output oriented analysis since most of the inputs considered, such as land and family labour cannot be easily increased or decreased in the short run according to production requirements. As mentioned above, land-holdings are a legacy of the apartheid and can therefore be considered

fixed given the absence of a well-functioning land market.

[5]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.

[6] The initial sample of 558 farm households, including all households conducting agricultural activities, have been reduced following the method proposed by Wilson (1993) in order to eliminate few outliers. Outliers are defined as observations with very low probability. The elimination of 9 outliers does not significantly affect the average estimated technical efficiency. Moreover, the inclusion of these outliers in the second stage analysis, does not significantly influence the results.

[7]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.

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

[9] Few exercises have been conducted to understand the sensitivity of technical efficiency estimates to the choice of alternative input and output bundles and of sample variations. When skilled and unskilled family members are considered as separated input of production average technical efficiency increases to 0.49. This increase is equally distributed across districts. As previously mentioned the use of a higher number of inputs (or outputs), relatively to the sample size leads to a higher number of households identified as "efficient". he fact that the average technical efficiency estimates do not change notably, i.e. average technical efficiency remains low, however suggests that failing to account for difference in labour quality at this stage of the analysis does not significantly alter the overall picture. To investigate whether the presence of districts with particularly favourable (or unfavourable) conditions are significantly affecting the estimates, technical efficiency scores have been re-estimated excluding each district at a time. The average estimates varies between 0.40, excluding ILembe district municipality, and 0.47, excluding eThekwini district municipality, which are the smallest and the largest district in the sample. The variation in the average estimates seems, therefore, to be mainly driven by the reduction in the

sample size.

[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.

[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) and education (Edmonds, 2006).

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

[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.

Tables

Table 1: Descriptive statistics of variables used for the estimation of efficiency

	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 labour (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

Table 2: Technical efficiency by district municipalities

District	Obs	Technical efficiency		%
		Mean	Sd	Efficients
Ugu	68	0.42	0.37	22.06
Umgungundlovu	26	0.43	0.36	23.08
Uthukela	65	0.45	0.37	24.62
Umzinyathi	30	0.32	0.32	10.00
Amajuba	39	0.44	0.39	20.51
Zululand	71	0.28	0.31	8.45
Uthungulu	92	0.38	0.36	16.30
iLembe	17	0.41	0.34	17.65
Vhembe	49	0.54	0.35	28.57
eThekwini	93	0.44	0.38	23.66
Total	549	0.41	0.36	19.64

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

Variables	Obs	Mean	Std. Dev.	Min	Max
Access to labour 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

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

Table 5: Analysis of household technical efficiency

	(1)	(2)	(3)	(4)$^{+}$	(5)	(6)$^{++}$
Household eligibility	0.105*	0.111*	0.111*	0.132*	0.113*	0.166*
	(0.059)	(0.060)	(0.061)	(0.072)	(0.061)	(0.088)
Share off-farm income	0.002***	0.002***	0.002***	0.002***	0.002***	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Household head (male)	0.015	0.047	0.103**	0.128**	0.105**	0.189**
	(0.033)	(0.042)	(0.044)	(0.052)	(0.044)	(0.081)
Age of household head	0.000	0.000	0.002	0.002	0.002	-0.008
	(0.010)	(0.010)	(0.010)	(0.013)	(0.010)	(0.015)
Education of head	0.002	0.002	0.002	0.001	0.002	-0.004
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.007)
Skills ratio	0.088	0.070	0.067	0.102	0.065	-0.045
	(0.091)	(0.090)	(0.083)	(0.106)	(0.083)	(0.157)
Title on land	0.053	0.051	0.046	0.053	0.046	0.095
	(0.037)	(0.037)	(0.036)	(0.043)	(0.035)	(0.064)
Employment rate (district)	0.003*	0.003*	0.002	0.003	0.002	0.003
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
Remittances					0.144	
					(0.257)	
Adults dummies		Yes	Yes	Yes	Yes	Yes
Age of oldest members			Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	549	549	549	549	549	255

Robust standard errors in parenthesis. All regressions include a constant, squared 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. $^{+}$ Tobit results. $^{++}$ excludes households participating in off-farm activities.

Table 6: Estimations dealing with the endogeneity of the income diversification index

	IV	OLS
	(1)	(2)
Household eligibility	0.200**	0.114*
	(0.080)	(0.065)
Share off-farm income	0.004*	
	(0.002)	
Household head (male)	0.061	0.135***
	(0.082)	(0.043)
Age of household head	0.001	0.004
	(0.016)	(0.011)
Education of head	0.011*	0.002
	(0.007)	(0.004)
Skills ratio	-0.149	0.130
	(0.135)	(0.084)
Title on land	0.056	0.049
	(0.053)	(0.036)
Employment rate (district)	0.002	0.002
	(0.002)	(0.001)
Adults dummies	Yes	Yes
Age of oldest members	Yes	Yes
District dummies	Yes	Yes
Observations	215	549

Robust standard errors in parenthesis. All regressions include a constant, the age squared, 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

Table 7: Robustness checks of the effect of the pension on TE

	(1)	(2)	(3)	(4)	(5)
Household eligibility	0.133**				
	(0.065)				
Share off-farm income	0.002***	0.002***	0.002***		
	(0.001)	(0.001)	(0.001)		
Person above eligibility		0.093*		0.174**	
		(0.049)		(0.073)	
Person below eligibility		0.044		0.070	
		(0.053)		(0.080)	
Woman age 45-50			0.105**		0.079
			(0.050)		(0.078)
Woman age 50-55			0.090		0.152
			(0.063)		(0.121)
Woman age 55-60			0.034		0.047
			(0.060)		(0.098)
Woman age 60-65			0.126*		0.181*
			(0.069)		(0.098)
Woman age 65-70			0.110*		0.239**
			(0.063)		(0.095)
Woman age 70 and over			0.114*		0.221**
			(0.067)		(0.107)
Adults dummies	Yes				
Age of oldest members	Yes				
Council dummies	Yes	Yes	Yes	Yes	Yes
Observations	537	549	549	255	255

Robust standard errors in parenthesis. *, ** and *** indicate significance at the 10%, 5%, and 1% level of significance. Control variables are omitted from the table