Technical efficiency of smallholder farmers in Malawi in the post-reform era: *Which policies matter most?*

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Abstract

The development of Malawian smallholder agriculture has since the 1980s gone through many challenges and there are fears that this may have been a precursor to unsustainable agricultural intensification and worsening poverty. In this paper, we conduct an empirical assessment of smallholder technical efficiency and its determinants using farm household and plot data. We use a non-parametric frontier analysis to analyze the technical efficiency of farmers in the maize-based mixed farming systems. In addition, we use a regression-based estimation to assess the socio-economic and policy related factors that may explain the estimated levels of technical efficiency. The results indicate low to medium levels of technical efficiency, depending on crop variety and soil fertility management option used. Higher levels of relative technical efficiency are obtained when farmers use integrated soil fertility options compared to the use of inorganic fertilizer only. Of the policy variables included in the analysis, agricultural input and output market, credit and extension access strongly influence smallholder technical efficiency. Government needs to resuscitate these public policy issues in order to effectively address sustainability of Malawian agriculture and its impact on poverty.

Keywords: Smallholder agriculture, technical efficiency, soil fertility management, Malawi

1. Introduction

Historically, smallholder agriculture has had the ability to stimulate pro-poor growth, as illustrated in the experiences of South East Asian Green Revolutions in the 1960s and 1970s (MOSLEY and SULEIMAN 2004). FREEBAIRN (1995) observed that although the early literature on the Asian Green Revolution was skeptical because initially uptake of hybrid wheat and rice was by larger farmers, it is widely acclaimed that the Green Revolution stimulated agricultural and overall economic growth that have

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accounted for a large share of the massive reduction in poverty in these countries over the last 30 years. This is due to three main reasons that have a direct bearing on poverty reduction: (i) smallholder agriculture is labour intensive and provides employment to producers and consumers alike, (ii) its ability to promote linkages to the rural non-farm sector, itself a labour intensive sector, (iii) possible reduction in the costs of goods which poor people largely consume.

Despite its central role in socio-economic development, smallholder agriculture in Malawi has been hampered by unimpressive technical performance, especially during and after the policy reform period (1980 onwards). Farmers now face multiple challenges, which in the short to medium term, can only be solved by raising agricultural productivity, especially given the scarcity of livelihood options outside agriculture. In this paper, we focus on the issue of raising agricultural productivity among smallholder farmers who have largely been crowded out of the agricultural input market, due to the increase in the relative price of inputs compared to output. There are fears that this may have compelled farmers to practice unsustainable intensification. As such, the central argument in this paper is that Malawi's smallholder agricultural productivity can be recapacitated through a combination of integrated soil fertility management and provision of public policy amenities such as credit and extension as well as infrastructure that support the efficient performance of input and output markets. To the extent that these options do improve the technical efficiency, they would provide scope for addressing the fears regarding unsustainable agricultural intensification and its obvious consequences on socio-economic development.

In addition, we also assess the socio-economic and policy related variables that determine technical efficiency under the alternative soil fertility management options. The significance of this study is two-fold. First and more importantly, since technical inefficiency reduces farmers' competitiveness by raising per unit costs, this study provides information that can contribute to the policy debate on cost effective ways of raising smallholder productivity[2]. Secondly, it provides information that is of potential use to researchers involved in soil fertility technology development and transfer. This is

[2] Finding ways of producing in a cost effective manner has been the center of debate in Malawi, especially in the face of declining agricultural terms of trade and the increase in the real prices of conventional inputs.

important in ensuring sustainable agricultural production, which is a critical issue in all attempts aimed at poverty alleviation in highly agrarian economies.

The rest of the paper is arranged as follows: the next section presents the policy environment in Malawi since 1980s and how it has generally impacted on the development of smallholder agriculture. This is followed by a review of related studies on factors that influence technical efficiency of smallholder farming systems in Malawi, with a focus on the period 1980-2000. Section four presents a theoretical discussion of non-parametric technical efficiency analysis upon which the analytical framework used in this study is based. Section five presents the data used in the analysis followed by section six which discusses the empirical results. Section seven concludes with main findings and their policy implications.

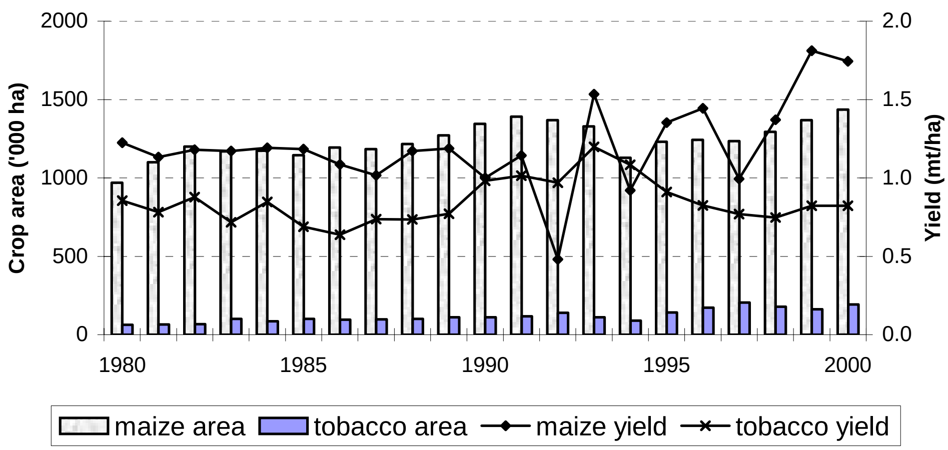
2. Agricultural policy environment in Malawi and its impact on smallholder farmers

Since 1981, the Government has implemented reforms aimed at the removal of distortions and biases against smallholder agriculture in order to create a conducive environment and improve access to productive resources among all groups of smallholder farmers. A significant element of all Structural Adjustment Program (SAP) loans Malawi accessed from 1981 to the early 1990s was to ensure an appropriate price policy in order to provide adequate incentives to producers and expanding the role of the private sector in the marketing of smallholder crops (BHALLA et al. 2000). Detailed discussion of Malawi's agricultural policy issues are provided in DORWARD et al. (2004a), DORWARD et al. (2004b) and KYDD and DORWARD (2001).

Despite the de-regulated agricultural production and marketing environment, the attainment of improved technical efficiency still remains largely elusive among the majority of the smallholder farmers. Available studies suggest little improvements or stagnation in terms of productivity gains in many smallholder crops and as a result the goal of self-sufficiency still remains largely unattained (CHIRWA 2003; ZELLER et al. 1998). For example, taking the case of the most important smallholder crops (maize and tobacco), Figure 1 gives a mixed productivity trend, measured as output per hectare. As observed by CHIRWA (2003), maize productivity has either marginally improved or remained stagnant since the 1980s until the 1990s in which we see an increased evidence of an oscillating pattern, despite government support towards the end of the decade[3]. In the case of tobacco, the substantial yield gains attained in the early 1990s more especially after the repeal of the Special Crops Act have been reversed as average tobacco yield has been declining since the mid-1990s.

Many studies attributed the lower levels of technical efficiency to the policy changes resulting from the structural reforms (OWUSU and NG'AMBI 2002; GOM 2002). However, in the spirit of a forward-looking policy agenda, there is need for agricultural policy makers to focus on understanding the levels of smallholder technical efficiency and the factors that determine it so as to better promote their performance in the post-reform era.

Figure 1: Maize and tobacco area and productivity in Malawi (1980-2000)



Source: FAOSTAT and Malawi Tobacco Control Commission.

3. Technical performance of smallholder farmers in Malawi and Sub-Saharan Africa (1980-2000)

Although there is vast empirical literature on the technical efficiency of farmers in the developed world and in Asia, few studies focus on Africa and of these even fewer

[3] Malawi with support mainly from the UK Department for International Development (DFID) has been implementing a Targeted Inputs Programme which involves the distribution of free fertilizer, maize and legume seed to all poor smallholder farmers since 1998/99.

focus on Sub-Saharan Africa (SSA). The very few studies that have analyzed the efficiency of SSA agriculture include ALDERMAN et al. (1995), HESHMATI and MULUGETA (1996), SEYOUM et al. (1998), TOWNSEND et al. (1998), WEIR (1999), WEIR and KNIGHT (2000), MOCHEBELELE and WINTER-NELSON (2000), CHIRWA and MWAFONGO (1998), FULGINITI et al. (1998), CHIRWA (2003) and SHERLUND et al. (2004) and OKIKE et al. (2004).

With the exception of TOWNSEND et al. (1998) who used a Data Envelopment Analysis (DEA) approach, most of these studies have used the parametric approach and assume mostly Cobb-Douglas and translog production functions. Most of these studies report low to moderate technical efficiencies that range from as low as 0.24-0.36 among farmers in Lesotho to 0.56 in Ethiopia, thus confirming the evidence that most countries in the developing world in general and SSA in particular, have been experiencing productivity declines in agriculture (FULGINITI et al. 1998).

Most studies have focused on analyzing the relationship between farm size and efficiency. While one would expect a positive relationship between farm size and technical efficiency due to the economies of scale argument, most studies have found an inverse or weak positive relationship (TOWNSEND et al. 1998; HESHMATI and MULUGETA 1996). Other factors that influence technical efficiency include farmers' education, extension, credit, market access and farmers' access to improved technologies through the market or public policy interventions. Some socio-economic variables such as gender of the farmers do not significantly influence efficiency, as reported by MOCHEBELELE and WINTER-NELSON (2000) in the case of Lesotho. However, ALDERMAN et al. (1995) found that gender plays an important role especially in SSA Africa where the participation of women in agriculture is higher than for men.

Other studies have extended the specification of the variables affecting efficiency to include environmental and ecological variables, because of the belief that not doing so may result in omitted variable bias that lead to over-estimation of technical inefficiency (SHERLUND et al. 2004; OKIKE et al. 2004). This is particularly important because most farming systems in SSA are rainfed and production decisions are greatly influenced by environmental factors such as on-set and cessation of rainfall.

In Malawi, the most comprehensive studies of smallholder technical efficiency have been conducted by CHIRWA and MWAFONGO (1996), CHIRWA (2003) and EDRISS et al. (2004). The first two studies have used data collected from a sample of farmers from Machinga Agricultural Development Division (ADD). EDRISS et al. (2004) used national level data to analyze the levels of technical efficiency in maize production given the labour market liberalization. All these studies used parametric approaches to estimate the efficiency and their findings of low to moderate levels of efficiency agree with those of other studies within the region and Africa as a whole. Our study complements these studies in a number of ways. First, the former two studies have been restricted to only one agro-ecological zone and their results may not be applicable to other agro-ecological zones, whereas our sample is drawn from three agro-ecological zones and we account for agro-ecological variations. Secondly, both studies have focused only on maize and have not been able to classify efficiency due to varietal differences. We have included in our analysis two most popular categories of maize varieties grown by smallholder farmers i.e. hybrid and open-pollinated varieties. Thirdly, in order to accommodate their choice of the parametric approach, both studies used a sub-sample of farmers that grew maize in a monocropping system. While this is correct for methodological convenience, in practice it is an unrealistic assumption because virtually every farmer engages in mixed cropping as a risk-averse behaviour to secure himself or herself against possible failure of one crop. The use of DEA approach allows us to consider relative efficiency within an intercropping system. Fourthly, we also include burley tobacco in the analysis because it is one of the key crops in the smallholder sub-sector. The fifth dimension that differentiates our study from the others is the consideration of alternative soil fertility management options available to smallholder farmers. This is important because while many alternative soil fertility management options have been developed for smallholder farmers, very little is known about their impact on improving the technical efficiency of farmers. The obvious weakness with the study by EDRISS et al. (2004) is the use of national level data that masks the farm-level variations. We improve on that by using farm-level data.

4. Estimation of technical efficiency and analytical framework

In the traditional theory of production economics, productive efficiency derives from technical as well as allocative or factor price efficiency. According to FORSUND et al. (1980), technical efficiency implies a combination of inputs that for a given monetary outlay maximizes the level of production. Whereas technical efficiency reflects the ability of the firm or farm to maximize output for a given set of resource inputs, allocative efficiency reflects the ability of the firm or farm to utilize the inputs at its disposal in optimal proportions given their respective prices and the available production technology.

There are a number of alternative approaches that are used to measure productive efficiency. The original approaches are based on what are called frontiers, as proposed by FARELL (1957). A frontier defines the maximum possible limit to observed production. The extent to which a farm's production is in relation to the frontier is taken as a conventional measure of its efficiency. Two types of frontiers have been used in empirical estimations: parametric and non-parametric frontiers. The former use econometric approaches to make assumptions about the error terms in the data generation process and also impose functional forms on the production functions while the later neither impose any functional form nor make assumptions about the error terms. Widely used examples of parametric frontiers are the Cobb-Douglas, the constant elasticity of substitution (CES) and the translog production functions. The most popular non-parametric frontier is the Data Envelopment Analysis (DEA), which has been used in FÄRE et al. (1994) and TOWNSEND et al. (1998). The principal advantage of DEA over the parametric approaches is that it can be used to analyze technical frontiers for multiple outputs and inputs, a characteristic of most smallholder farming systems. As such due to the need to incorporate multi-output and input systems, given the risk-averse behaviour of Malawian smallholder farmers, and the integrated nature of the soil fertility management options, we chose the DEA approach.

DEA is one of the widely used approaches to calculate a 'best-practice' production frontier (COELLI et al. 1998; KUMBHAKAR and LOVELL 2000). The initial DEA was introduced by CHARNES, COOPER and RHODES in 1978 as an improvement to the single-input, single-output model developed by FARELL in 1957.

Both input and output distance functions are used to characterize the frontier of a multiple-input, multiple-output production technology and the proportional distance of each observation from the frontier is used to calculate the efficiency.

Following the model by HELFAND and LEVINE (2004), we assume a production possibilities set C that is a combination of all pairs of inputs x and feasible outputs y. The production possibility set is assumed to be non-empty, closed and convex and that inputs and outputs are freely disposable. We define an input distance function X_0 as:

$$X_0(x,y) = \inf\left\{\mu : \left(x, \frac{1}{\mu}y\right) \in C\right\} \qquad [1]$$

where μ is a strictly positive scalar that measures the ratio of the observed vector of inputs to the minimum vector that could be used, to achieve the same level of output vector. The outcome is called the Farrell measure of efficiency, which is equal to unity for efficient firms or farms. Hence the further away it increases from unity, the greater the level of inefficiency.

DEA analysis is formulated as a linear programming problem under alternative assumptions about the returns to scale. Following FÄRE et al. (1994), we assume Z household farms, producing K outputs, using N inputs under constant returns to scale (CRS)[4]. With the above assumptions, we solve the following linear program for each household farm:

$$\underset{\mu,z}{Min}\ \mu \qquad [2]$$

s.t.

$$\mu_z y_{kz} \leq \sum_{z=1}^{Z} w_z y_{kz}, \quad k = 1,..........K \qquad [3]$$

$$\sum_{z=1}^{z} w_z x_{nz} \leq x_{nz} \qquad n = 1,........N \qquad [4]$$

$$w_z \geq 0 \qquad z = 1,..........Z \qquad [5]$$

where w_z are weight variables that show the intensity with which each household farm is used in the construction of the frontier of production possibilities. The linear program

[4] The Variable Returns to Scale (VRS) analysis is also conducted for comparison.

solves for the minimum value of the intensity score μ given the imposed constraints [3] and [4] which state that all possible vectors of inputs and outputs are feasible and that the intensity variables are non-negative as given in equation [5].

After the estimation of the efficiency score, we use ordinary least squares (OLS), to assess the factors that influence the variation of the efficiency score. Although OLS has been found to be inappropriate because of the non-normality of the efficiency score variable, in our case we transform the score to a percentage by multiplying the inverse of the score by 100%, thus generating a continuous variable that does conform to the normality assumption as shown in the plot of residuals in Annex 1.

It is important to note that there may be many factors that could prevent a farm to operate on the best practice frontier. Furthermore, efficiency scores may also be sensitive to the errors in measurement, especially for those farms that define the frontier. We have dealt with these issues in the empirical application of the model and the details regarding the measurement and specification of variables that influence efficiency is presented in the next section[5].

5. Data

The main data set used for the analysis is the farm household and plot level data collected from nearly 376 households (or 573 plots) in Mzuzu, Lilongwe and Blantyre Agricultural Development Divisions (ADD) from May to December 2003[6]. A two-stage stratified random sampling approach was used to draw the sample. In each ADD, the sampling focused on one Rural Development Project (RDP) from which two Extension Planning Areas (EPA) were chosen, one in an easily accessible area and another from a

[5] The model has been implemented in Generalized Algebraic Modeling System (GAMS) and the code may be obtained from the authors upon request.

[6] Malawi's agricultural extension administration is channeled through a hierarchy of levels of agro-ecological zones starting with an Agricultural Development Division (ADD) at a regional level, a Rural Development Project (RDP) at a district level and an Extension Planning Area (EPA) at a local level. EPAs are further sub-divided into sections that are manned by frontline extension staff that are in direct contact with farmers. There are eight ADDs, 28 RDPs and over150 EPAs. Our choice of the three ADDs was purposefully done for two main reasons: (i) these are well representative of Malawi's diverse farming systems, in terms of production potential and heterogeneity in resource endowments, more especially land, with Blantyre ADD being the most land constrained (ii) these agro-ecological zones have adequate numbers of smallholder farmers who have been involved in soil fertility improvement programmes, involving both public institutions and non-governmental organizations for over a decade.

remote area. A representative sample for each enumeration area was obtained through a weighting system in which district population and population density were considered.

Table 1 presents the definitions of the variables we have used in the analysis, how they were measured and their descriptive statistics. In the estimation of efficiency, we have included the crop combinations that best characterize smallholder farming systems in Malawi. Maize is grown on over 80% of the land under subsistence farming systems, making Malawi the world's highest per capita consumer of maize (SMALE and JAYNE 2003). While most farmers still grow local maize varieties, there has been an increase in the number of farmers that have been growing either open pollinated varieties (OPV) or hybrids. In our sample, 98.6% and 41.5% of the farmers grew local or OPVs and hybrid maize varieties, respectively. Burley tobacco has also increasingly become the most important cash crop among smallholder farmers, following the repeal of the Special Crops Act that allowed smallholder farmers to grow burley tobacco, which hitherto was an estate crop. In our sample, about 32.5% of the farmers grew tobacco during the 2002/2003 season. Other dominant crops include pulses that are mostly grown in intercropping systems, often with maize as the main crop. We have considered the pulses that also have soil fertility attributes through biological nitrogen fixation. In the analysis we have included beans and groundnuts because of their higher relative frequency in farmers' plots than other crops i.e. 18.3% and 29.3% of the farmers grew beans and groundnuts, respectively. Other intercrops include roots and tubers such as cassava and sweetpotatoes. We have not considered these in the analysis because they only dominate the intercropping systems in Blantyre ADD where land is relatively a more binding constraint than other ADDs due to high population density.

The main input variables include land, measured as total cultivated land for each household and labour that is measured as the total mandays devoted to crop production including that which is hired. We also include the total amount of fertilizer acquired by the household in the given season. In analyzing the factors that influence efficiency, we have included socio-economic and policy related variables as well as plot level biophysical factors and location agro-ecological dummies. The specification of most of these is based on literature (c.f. SEYOUM et al. 1998; CHIRWA 2003; HELFAND and LEVINE 2004; OKIKE et al. 2004). For example among the socio-economic variables, most studies have cited gender, age and education of the household head as having considerable influence on agricultural performance. Among the policy related variables, access to credit, markets and extension feature highly in most policy discussions regarding agricultural performance. As discussed earlier, Malawi has gone through a number of challenges in the previous decade that have greatly influenced farmers' access to such public policy support. For example, there has been a change in the administration of smallholder credit from a state-sponsored Smallholder Agricultural Credit Administration (SACA) to a more private oriented credit institution, the Malawi Rural Finance Company (MRFC). Marketing of agricultural inputs and outputs has been completely deregulated from the state-sponsored parastatal, the Agricultural Development and Marketing Corporation (ADMARC), which is also undergoing substantive changes towards commercialization. There has also been drastic reduction in public support in the provision of agricultural extension[7].

We also include a dummy of the soil fertility management option adopted by the farmers. We differentiate between integrated management, which involves the use of inorganic fertilizer and the low-cost 'best-bet' options such as grain legumes e.g. groundnuts (*Arachis hypogea*), soybeans (*Glycine max.*), pigeon peas (*Cajanas cajan*) and velvet beans (*Mucuna pruriens*) and the use of inorganic fertilizer only as the main input. In order to assess the impact of cropping pattern on efficiency, we have also included a dummy on crop mix that specifies whether the farmer practiced mixed or monocropping. The location dummies (LDUMMY) are used to capture the influence of agro-ecological zone on efficiency. Subsumed in this are fixed location specific factors such as local weather conditions and other spatial attributes.

6. Results and discussion

As shown in Figure 2, the mean relative technical efficiency among smallholder farmers is 58.5% with a standard deviation of 23.8%. Farmers that adopt integrated soil fertility options have a higher relative technical efficiency compared to those that only apply inorganic fertilizer, estimated at 62.8%. For the case of constant returns to scale,

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[7] In aggregate terms, the public expenditure in agriculture has declined from about 12% of total public expenditure in the early 1990s to about 5% after 2000 (FOZZARD and SIMWAKA 2002).

Table 1: Variable definition and descriptive statistics*

Variable	Description	Unit of measurement	Mean	Std.
Efficiency estimation				
QMMAIZE	Local / OPV maize output	Kg	391.7	412.7
QHMAIZE	Hybrid maize output	Kg	956.4	895.2
QTOB	Burley tobacco output	Kg	1375.1	1053.2
QINT1	Output of first intercrop	Kg	106.2	119.9
QINT2	Output of second intercrop	Kg	213.0	199.4
LAND	Total crop area	Ha	1.0	0.9
LABOUR	Family and hired labour used	Mandays	156.3	27.2
FERT	Amount of fertilizer applied	Kg	48.4	57.7
Factors affecting efficiency				
GENDER	Gender dummy	1=male; 0=female	0.7	0.5
AGE	Farmer's age	Years	43.6	15.7
EDUCATION	Farmer's education	Years	3.6	1.2
EXTENSION	Extension access	No. of visits / month	0.5	0.9
CREDIT	Credit access	MK/household / year	814.1	3742.9
MACCESS	Market access	Distance (km)	0.2	0.4
SFM	Soil fertility mgt. option dummy	1=integrated; 0=fertilizer only	0.4	0.5
CROPMIX	Crop mix dummy	1=mono; 0=mixed	0.4	0.5
INPCOST	Proportionate input cost	% of total crop income	5.3	6.0
FMORG1	Market-based farmer organization	1=yes; 0=no	0.4	0.5
FMORG2	Credit-based farmer organization	1=yes; 0=no	0.5	0.5
SOILDEPTH	Topsoil depth (cm)	Cm	16.3	2.9
NITROGEN	Total nitrogen	%	0.11	0.1
ORGMATTER	Total organic matter	%	1.06	0.5
BULKDNY	Bulk density	G / cm^3	1.6	0.3
WEEDING	Weeding frequency	No. of weedings	1.3	1.1
PLANTING	Date of planting	1=with first rains; 0=later	1.7	0.5
LDUMMY1	Agro-ecological zone dummy	1=Mzuzu; 0=others	0.4	0.5
LDUMMY2	Agro-ecological zone dummy	1=Lilongwe; 0=others	0.3	0.5
LANDPRES	*Land pressure*	*mandays /ha*	194.6	222.5
FSI	*Food security index*	*% of food requirement satisfied*	48.4	31.7

Note: * figures are rounded to one decimal place

this implies that the relative productivity of farmers that apply integrated soil fertility management is higher than those that apply inorganic fertilizer only. Among other reasons, increased relative technical efficiency among farmers that apply integrated soil fertility management options may be attributed to harvesting of several crops (i.e. maize or tobacco and the legume intercrop). This raises the overall plot productivity, thereby raising the weighted output component of the relative efficiency equation. Secondly, grain legumes contribute to soil productivity through biological nitrogen fixation, thereby lowering the effective cost of soil fertility management.[8]

These results somehow correspond to those reported by CHIRWA (2003) i.e. mean technical efficiency level of 53.1% with a standard deviation of 35.3%. Our results should be expected to be slightly higher because we used a deterministic approach that does not take into account the random errors.

The results from the OLS regression presented in Table 2 clearly indicate that application of integrated soil fertility management option significantly improve relative technical efficiency. As already indicated, higher productivity of integrated systems coupled with the fact that they are likely to be multi-output systems, raises overall per unit productivity of land, which is consistent with higher technical efficiency.

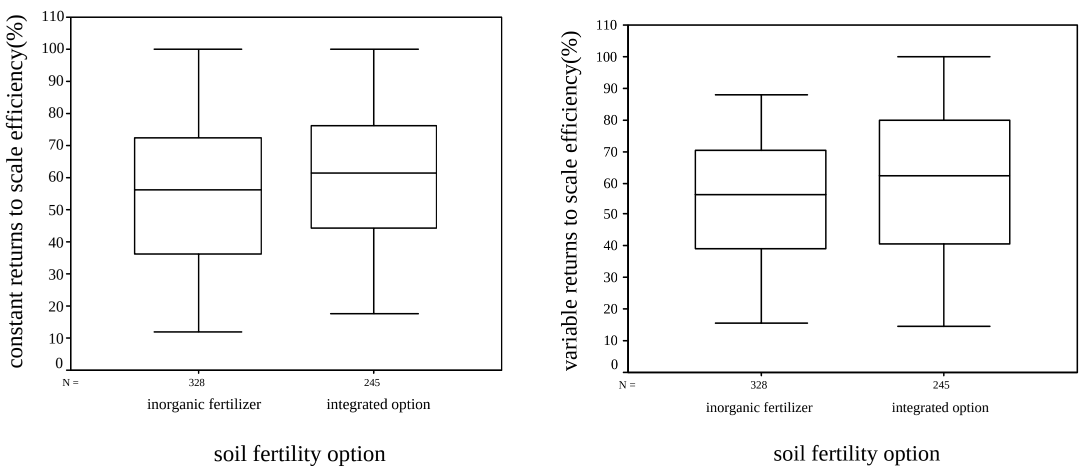
Among the socio-economic variables, only household size and education are significant. The significance of household size may be attributed to labour availability, an important aspect in ensuring that all important husbandry practices such as weeding, which highly influence productivity are conducted in time. In the case of education, empirical evidence in SSA indicates that with improved human capacity due to education, farmers' ability to take up farming innovations improves firstly because of their increased level of aptitude and secondly because well educated farmers are likely to be highly receptive of agricultural innovations, and are thus targeted by both public and non-governmental extension services (ADESINA 1996; ADESINA and ZINNAH 1993 and ADESINA et al. 2000). These factors tend to increase the productivity of educated farmers than those that are illiterate.

Almost all the policy variables are positively and significantly related to technical efficiency. These results confirm the evidence from existing literature that policy interventions that affect market, credit and extension are likely to affect farmer performance because these factors reinforce each other to influence the effective benefits from and costs of farming. Farmers' decisions regarding soil fertility management and

[8] Using a yield response function analysis of the same dataset, TCHALE (2004) found that at every rate of inorganic fertilizer, farmers that incorporate grain legumes attain higher yields (a higher response) than those that use inorganic fertilizer only.

other investments in farming are greatly influenced by the incentives that emanate from the effective costs and benefits they face (WEIGHT and KELLY 1998).

Figure 2: Distribution of relative technical efficiency by returns to scale assumptions



Among the biophysical factors, soil depth and % total nitrogen are significant and all have expected signs. Both these factors are critical in improving crop yield and as such they are expected to be positively related to the efficiency score. The husbandry practices, such as frequency of weeding and early planting (with first rains) are also significant at 1% and 5%, respectively. Evidence from agronomic research conducted in Malawi and SSA region indicate that these are the most crucial husbandry practices that have the potential to affect yields considerably (KUMWENDA et al. 1997).

The impacts of the two agro-ecological dummies on technical efficiency are not surprising, although their signs are somewhat different from expectations. Farmers that are located in Mzuzu ADD are found to be relatively less efficient compared to those of Lilongwe and Blantyre ADD, mostly because of the higher land holding sizes relative to their levels of production. There is vast literature indicating that land holding size is either inversely or insignificantly positively related to technical efficiency (HESHMATI and MULUGETA 1996; TOWNSEND et al. 1998; HELFAND and LEVINE 2004).

Table 2: OLS estimates of the factors affecting relative technical efficiency among smallholder farmers in Malawi (CRS scores)

Variable	Coefficient (standard error)	P-value
Household socio-economic characteristics		
SEX (1=Male; 0=female)	0.08(1.12)	0.90
AGE (Years)	-0.01(0.04)	0.80
HHSIZE (Number of people)	0.49(0.24)	0.04
EDUCATION (years of formal schooling)	0.61(0.10)	0.00
Soil fertility management and cropping pattern		
SFM (1=integrated; 0=inorganic fert. Only)	17.36(1.68)	0.00
Cropping pattern (1=mixed; 0=mono)	2.80(2.04)	0.17
Policy and institutional variables		
Market access (1=good; 0=poor)	2.27(0.31)	0.00
Credit access (average loan amount MK)	1.37(0.44)	0.03
Extension access (No. of visits per month)	12.61(8.62)	0.08
Input cost (% of total crop income)	-0.32(0.10)	0.00
Market-based farmer organization (1=yes; 0=no)	4.76(4.54)	0.29
Credit-based farmer organization (1=yes; 0=no)	10.95(4.41)	0.01
Biophysical plot level factors and husbandry practices		
Topsoil depth (cm)	0.09(0.05)	0.04
% total nitrogen	0.04(0.02)	0.04
% total organic matter	0.39(0.93)	0.54
Bulk density (g / cm^3)	-0.31(0.99)	0.75
Weeding frequency (No. of weedings)	0.33(0.03)	0.00
Date of planting (1=with first rains; 0=later)	0.02(0.01)	0.05
Location specific variables		
Mzuzu Agricultural Development Division	-5.47(1.48)	0.00
Lilongwe Agricultural Development Division	0.22(1.49)	0.88
Other control variables		
Land pressure (mandays /ha)	0.05(0.03)	0.05
Food security index (% of food requirement satisfied)	0.06(0.02)	0.00
Constant	67.10(12.46)	0.00
Adjusted R^2	0.49	
F-value	24.46	0.00

Note: Number of observations (N) = 573

We also controlled for land pressure and food security. The results on land pressure are consistent with expectations because farmers that face considerable land pressure are highly likely to find ways of efficiently increasing output in order to maintain their livelihoods. TCHALE and WOBST (2004) in another analysis using the same dataset also found a significant and positive relationship between land pressure and adoption of integrated soil fertility management options. This is also supported by other literature, such as the induced innovation hypothesis, more especially under the availability of supportive policy environment (c.f. BOSERUP 1981). Households that are food secure are also likely to be efficient because unlike those that are food insecure, they are less likely to neglect their fields in order to engage in coping or survival strategies that mostly involve selling their labour to other farms or estates.

The main focus of the paper was to assess the extent to which changes in public policy towards smallholder farmers implemented in the previous decade might influence their technical efficiency. In Table 3, we compare the changes in technical efficiency (keeping all variables at their means) given the key policy related variables such as improved market, credit and extension access as well as ability to grow hybrid maize or burley tobacco. We also compare the technical efficiency change between farmers that apply inorganic fertilizer only and those that apply integrated soil fertility management options. The results indicate that adoption of integrated soil fertility management options increases relative technical efficiency by 7.3% and 14.2% assuming constant and variable returns to scale (CRS and VRS), respectively. Farmers that grow hybrid maize are about 5% more efficient than those that grow local or open pollinated maize varieties. This is attributed to the higher response of hybrid maize varieties to inputs, and thus higher productivity. Also due to the higher productivity argument, growing of burley tobacco also increases technical efficiency, although the effect is lower and not significant compared to farmers that do not grow tobacco.

Technical efficiency of farmers who are located nearer to produce and input markets is 12.5% and 5.1% higher, than that of farmers in remote areas, assuming CRS and VRS, respectively. Improved access to credit and extension also similarly improve technical efficiency, supporting the findings of other studies (CHIRWA 2003).

Table 3: Key variables that influence relative smallholder technical efficiency

Key variable	% change in predicted relative technical efficiency	
	Constant returns to scale	Variable returns to scale
Integrated soil fertility management	+14.2***	+7.3***
Growing hybrid maize	+5.8***	+4.4*
Growing burley tobacco	+0.4	+4.9*
Improved market access	+12.5***	+5.11**
Improved credit access	+4.6*	2.28
Improved extension access	+9.3***	2.58

Note: *P-value<0.10; **<0.05; ***<0.001

7. Conclusions and policy implications

There is need for renewed and committed focus to address problems affecting smallholder agriculture because evidence from the literature indicates that any growth strategy that neglects a consistent consideration of pro-poor issues is unlikely to succeed given the inherent weaknesses of the economic environment. The experience in Malawi, as in many other developing countries, is that getting the prices right is not sufficient in the absence of adequate investment in public goods as well as appropriate technology. The changes that have unfolded in the course of policy reforms in the past decade have impacted negatively on the technical efficiency of the farmers leading to continuously declining yields and widespread food insecurity and poverty, which ultimately threaten the sustainability of agro-based livelihoods.

Results from this study indicate that improvement in market access and provision of agricultural credit along with extension services are likely to lead to improved smallholder technical efficiency. Furthermore, improved extension provides the most effective caveat for widespread adoption of low-cost soil fertility management technologies already developed by researchers, which - when combined with inorganic fertilizers- provide a glimpse of hope in resuscitating the productivity of the maize-based smallholder farming systems. Given the escalating prices of inorganic fertilizers, integrated soil fertility management options reduce the effective cost of soil fertility management options, thus making inorganic fertilizers and improved crop varieties more affordable.

Policy implications drawn from these results include a review of agricultural policy with regard to the issue of smallholder agricultural credit provision, given that the current system has crowded out smallholder farmers due to the market determined interest rates, among other reasons. There is also need for renewed public support to revamp the agricultural extension system, which has been neglected since the mid 1990s. Only recently, its impact is increasingly being felt especially due to high attrition rates as a result of the HIV/AIDS scourge. Equally important are interventions towards improving market infrastructure in order to reduce the transaction element in the input and output marketing. Furthermore, there is need for deliberate policy intervention to promote private sector involvement in agricultural input and output market, so as to fill up the void created by the commercial focus of ADMARC, which resulted in the closure of many marketing outlets especially in the remote areas. The government needs to promote a forward-looking policy agenda that avoids inconsistent signals through the unwarranted interventions and policy reversals that mostly disrupt market development. More importantly, this implies that while embracing the salient features of a market environment, the government needs to level the playing field through the creation of the much-needed public goods as a precondition, which will ultimately provide incentives and ability to farmers to manage their farms sustainably. Without a structural breakthrough in economic development, which is an unlikely scenario in the foreseeable future, this is the only pathway that will have a long-lasting impact on poverty reduction in Malawi.

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Annex 1: Plot of standardized residuals from OLS regression