Available online at www.sciencedirect.com
SCIENCE DIRECT®
Agricultural Economics 29 (2003) 99–109
AGRICULTURAL ECONOMICS
www.elsevier.com/locate/agecon

Access to credit, plot size and cost inefficiency among smallholder tobacco cultivators in Malawi

Gautam Hazarika [a,*], Jeffrey Alwang [b,1]

[a] *Department of Business Administration, The University of Texas at Brownsville, 80 Fort Brown, Brownsville, TX 78520, USA*
[b] *Department of Agricultural and Applied Economics, Virginia Tech, Blacksburg, VA 24060, USA*

Received 8 May 2001; received in revised form 14 August 2002; accepted 15 August 2002

Abstract

Using data from the Malawi Financial Markets and Household Food Security Survey, this paper examines the effect of access to credit from formal sources, and tobacco plot size, on cost inefficiency among Malawian smallholder tobacco cultivators. Farm-specific cost inefficiency is estimated within the framework of stochastic frontier analysis. Access to credit is measured as the sum of household members' self-reported credit limits at credit organisations, arguably a truer measure of an exogenous credit constraint than credit program participation or actual loan uptake. It is found that tobacco cultivation is significantly less cost inefficient per acre on larger plots. While access to credit by itself has no statistically discernible effect on cost inefficiency, it reduces the gain in cost efficiency from a larger plot size.

JEL classification: O130; Q120

Keywords: Tobacco; Malawi; Plot size; Agricultural finance; Cost efficiency

1. Introduction

Improvement in the efficiency of agricultural production, including productivity growth, is an essential component of any rural growth strategy. In sub-Saharan Africa, where price-based adjustment policies have not led to broad-based economic growth, gain in the efficiency of agricultural production is viewed as necessary for economic growth and the alleviation of rural poverty. Rural finance may contribute by facilitating the purchase of costly inputs and the adoption of alternative crops. Besides, financial services may be packaged to deliver technical expertise. Improved access to rural finance may, thus, be associated with increased productivity and decreases in cost inefficiencies.

Conditions in Malawi underscore the potential benefits of improved efficiency in agricultural production. Malawi is among the 10 poorest countries in the world, with a GNP per capita estimated at US$ 190 (World Bank, 2000) and social indicators that are consistent with widespread poverty. The country is predominantly rural: <25% of the population resides in urban centres—and agriculture dominates the rural economy. Malawian agriculture is characterised by extreme dualism: smallholders under traditional tenure on the one hand, and either lease- or free-held estate farms on the other, constitute the major tenure

* Corresponding author. Tel.: +1-956-544-8953; fax: +1-956-548-8736.
E-mail addresses: ghazarika@utb.edu (G. Hazarika), alwangj@vt.edu (J. Alwang).
[1] Tel.: +1-540-231-6517; fax: +1-540-231-7417.

0169-5150/03/$ – see front matter
doi:10.1016/S0169-5150(03)00020-3

types. Estate farms were viewed through the 1970's and 1980's as the engines of rural growth, and the former Banda dictatorship used policies that favoured the estates. These policies included exclusive marketing rights for high-value crops, other marketing policies that squeezed smallholders, and access to subsidised inputs and credit. While Malawian agricultural growth was fairly strong during the 1970's and early 1980's, this growth was illusory since it did not spread to the smallholder sector. Smallholders currently constitute around 70% of the Malawian population and about 90% of the country's poor. The median area under cultivation by smallholders is a mere 0.6 ha (World Bank, 1995). The high concentration of poor in rural areas with small landholdings helps justify the government's current focus on agricultural intensification among smallholders as an engine of poverty-reducing growth.

Recent policy reforms designed to benefit smallholders have focused on two crops: hybrid maize varieties and burley tobacco. Malawian smallholders devote some 70% of their land to maize, mostly local varieties. Hybrid maize has not been widely adopted for several reasons, including the fact that the preferred flinty hybrids only became available in the early 1990's, the high relative cost of fertiliser, and lack of credit. The new policy reforms are expected to promote uptake of hybrid maize and, thus, release land for production of more profitable and mostly export crops. Burley tobacco is the most likely candidate to replace maize acreage. Burley tobacco is currently grown on some 150,000 ha of land and accounts for at least 70% of Malawi's foreign exchange earnings (about US$ (mUS$) 375 million, annually). The importance of this crop to the Malawian economy has earned it the sobriquet 'green gold'.

Until recently, the Government of Malawi promoted production of high-value cash crops like tobacco in the estate sector. Prior to 1990, under the Special Crops Act of 1972, smallholders were prohibited from marketing tobacco. Smallholders' share of tobacco quotas has, however, increased since 1990. Smallholder marketing quotas were first offered in the post-reform era to members of tobacco growers' clubs. An intermediate buyer program was introduced in 1993 that allowed even non-members of tobacco clubs to sell tobacco to registered traders. The number of smallholders producing tobacco has significantly increased as a result of these policy changes (Zeller et al., 1997).

The smallholder burley tobacco program reflects a substantial change in the Malawian agricultural development strategy away from estate-led growth toward a broad-based smallholder focus. Burley tobacco is now seen as an engine that will provide resources to cash-starved smallholders, will integrate them into the cash economy, and allow flexibility and experimentation in the rural sector. The success of the program depends upon the spread of burley tobacco production to resource-poor farmers, the ability of smallholders to efficiently produce high-quality tobacco products, and complementaries between tobacco production and other on-farm enterprises.

By examining the relationship between plot size and cost inefficiency per acre in tobacco production, this paper aims to discover whether the government's promotion of smallholder tobacco cultivation has involved an equity-efficiency trade-off. A negative relation between cost inefficiency and tobacco plot size would suggest that the policy of de-emphasising tobacco production in the estate sector while encouraging it in smallholdings has fostered equity at the expense of efficiency.

This paper also examines the effect of smallholders' access to credit upon their efficiency in tobacco production. It is well known that the capital requirements of tobacco farming are substantial. For example, Zeller et al. (1997) find that input expenditures per hectare in Malawi are much greater for tobacco than for maize or most other crops and that the cropping share of tobacco in smallholdings is positively and significantly correlated with farmer access to credit. Hence, improving access to credit may be a necessary step toward achieving more widespread burley tobacco production. However, besides encouraging the spread of tobacco production, improved credit access may raise efficiency in tobacco farming by enabling farmers to better purchase inputs in cost minimising proportions and to avail of improvements in production technology. The relationship between credit availability and economic efficiency in the Malawian smallholder tobacco sector has not previously been thoroughly investigated.

The paper's empirical strategy, utilising data from the Malawi Financial Markets and Household Food Security Survey, consists of two steps, though in

keeping with recent econometric advances, the paper later attempts to combine the two steps into a single step. First, farm-specific cost inefficiency per acre is estimated within the framework of stochastic frontier analysis (e.g. Parikh et al., 1995). Next, the estimated cost inefficiency is related to farm and household characteristics including tobacco plot size and access to credit from formal sources. It is found that cost inefficiency is negatively and significantly correlated with tobacco acreage. Hence, the government's focus on smallholder led growth may indeed have involved an equity-efficiency trade-off. It is also found that while access to credit by itself has no statistically significant effect on cost inefficiency, credit availability has the counter-productive effect of reducing the gain in cost efficiency from an increase in tobacco acreage.

The remainder of this paper is organised as follows. Section 2 presents a discussion of the relation between credit access and cost efficiency in agriculture. The section also discusses empirical issues in the measurement of access to credit. Section 3 presents the econometric model and discusses estimation. The data are described in Section 4, as are the empirical results. Section 5 presents a summary of the findings and the paper's conclusion.

2. Credit programs and cost efficiency in agriculture

Cost efficiency results from both technical efficiency and allocative efficiency. Technical efficiency refers to a producer's ability to obtain the highest possible output from a quantity of inputs. Consider a unit isoquant with capital and labour as the inputs. This isoquant is the locus of the minimum capital–labour combinations necessary to produce a unit of output. Hence, production is technically efficient along it. The producer of a unit of output using a capital–labour combination that lies above this isoquant is, therefore, technically inefficient.

Allocative efficiency refers to a producer's ability to maximise profit given technical efficiency. A producer may be technically efficient but allocatively inefficient. For example, the producer in the preceding paragraph may put forth a unit of output using a combination of capital and labour that lies on the unit isoquant but that is more expensive than a different combination of inputs on the isoquant. The cheapest input combination would, of course, be the point of tangency between an isocost line and the unit isoquant. Allocative efficiency also applies to the producer's ability to choose the optimal level of output, or even the optimal output mix.

Access to credit may raise allocative efficiency in agriculture. For example, a farmer unable to obtain market inputs in sufficient quantities may substitute non-market inputs such as the labour of family members. However, given the opportunity cost of family labour, the farmer's input combination may be more costly than an alternative combination consisting of more purchased inputs and less family labour. Credit may allow the farmer to utilise market and non-market inputs in a cost minimising combination. Credit may also raise allocative efficiency by increasing a farmer's ability to bear risk. For example, a farmer with access to credit may become willing to adopt riskier but potentially more profitable technologies, or to plant a more drought prone but higher value crop.

Credit access may also raise the farmer's level of technical efficiency. For example, credit may enable a farmer to adopt more capital-intensive methods of production, i.e. to purchase more machines, a market input. If the farmer purchased new machines embodying improved technology, his level of technical efficiency would rise. Further, to the extent that credit access is correlated with the provision of technical assistance (agricultural extension services) by credit organisations, farmers' technical efficiency will increase. Note that it is not necessary for a farmer to actually borrow to benefit from credit access. For example, the mere option of borrowing may lead a farmer to avoid such risk reducing but unprofitable strategies as precautionary saving and the production of hardier but lower value crops. Hence, a farmer with the option to borrow may become willing to put the proverbial roll of bills in his mattress to a more productive use on the farm.

Access to credit has generally been measured in two ways in the literature, namely, dichotomous membership in credit programs, and actual loan uptake. Both these measures may be unsuitable for estimating the true causal effect of credit access on economic outcomes (e.g. David and Meyer, 1980; Feder et al., 1990; Zeller et al., 1996). First, since credit program participation and loan uptake are voluntary, the measures are potentially endogenous with outcomes such as

productivity and income. A farmer who avails of loans from a credit agency may be found to be more productive, but it may not be concluded that loans lead to higher productivity since it is plausible that farmers with more ambition and ability are likelier to seek out loans. Such traits, being unobserved, are unlikely to be controlled for in a regression relating agricultural productivity to farmer loan uptake, with the result that the regression's error term, consisting partially of unobserved farmer traits, will be correlated with loan uptake. Bias in the OLS estimate of the effect of farmer loan uptake on agricultural productivity is, therefore, likely.

Even if the potential endogeneity of actual loan uptake were dealt with, difficulties with this measure of credit access would persist. For example, inherent in it is the erroneous assumption that individuals with no loan uptake are without access to credit. However, this would only be true if they were denied loans. More generally, actual loan uptake would be an accurate measure of credit access only if credit limits were universally binding, i.e. if everyone's loan uptake were equivalent to her credit limit. In reality, individuals often do not fully exercise their option to borrow. Indeed, as discussed earlier, an individual who does not at all exercise the option to borrow may yet benefit from that option, for example, by feeling secure enough to adopt potentially more profitable but riskier strategies.

Next, membership in a credit program often confers benefits unrelated to credit access such as literacy classes and business training. For example, members of the Malawi Rural Finance Company's (MRFC) credit program are provided with agricultural extension services. These secondary benefits of credit program participation arguably confound the true causal effect of access to credit. Finally, mere membership in a credit program may not guarantee ready access to credit. Indeed, many group-based credit programs stipulate that only half of a group's members may receive credit at any time. Even credit programs disavowing this rule rarely provide their members with certain access to credit.

Hence, Diagne (1998) and Diagne and Zeller (2001) argue that the credit limit, the maximum amount that may be borrowed as self-reported by survey participants, is a better measure of credit access. The authors reason that unlike credit program participation or actual loan uptake, which are related to demand for credit, the credit limit, reflecting mainly supply-side factors such as the availability of credit programs and the financial resources of lenders, is a truer measure of an exogenous credit constraint. Thus, this paper measures a tobacco producing household's access to credit by the sum of the credit limits of its members at credit organisations.

To be sure, this relatively novel measure of credit access is not unambiguously exogenous (uncorrelated with unobserved borrower characteristics). For example, Diagne (1998) accedes that the maximum amount that lenders are willing to lend will mirror their assessment of the likelihood of default and other borrower characteristics. Hence, an efficient tobacco farmer may have a higher self-assessed credit limit than an inefficient one. The OLS estimated effect of credit access on cost inefficiency might, thus, be biased downward. On the other hand, since an objective of non-profit agro-financial institutions in LDCs may be the reduction of economic inefficiency, more inefficient farmers may be rendered greater assistance. The OLS estimated effect of credit access on cost inefficiency might, as a result, even be biased upward. Nevertheless, it is plausible that the credit limit measure of access to credit is relatively more exogenous than actual loan uptake or dichotomous membership in credit programs, which are deliberate acts on the part of borrowers and, therefore, almost certainly correlated with their unobserved attributes.

3. The econometric model

Consider the stochastic cost function based on the composed error model (e.g. Aigner et al., 1977);

$$\ln C_i = \alpha + \beta \ln Q_i + \sum_{j=1}^{n} \delta_j \ln P_{ij} + \varepsilon_i \tag{1}$$

where C_i represents household i's cost per acre of tobacco production, Q_i denotes the value in monetary units of the household's tobacco output per acre,[2] P_{ij} signifies the household-specific price of variable input

[2] The existence of multiple tobacco types necessitates measurement of tobacco output per acre in monetary rather than physical units.

i, and ε_i is a disturbance term consisting of two independent elements as follows:

$$\varepsilon_i = V_i + U_i \tag{2}$$

V_i, assumed to be independently and identically distributed as $N(0, \sigma_V^2)$, represents random variation in cost per acre due to extraneous factors such as the weather and crop diseases. The term U_i is taken to represent cost inefficiency relative to the stochastic cost frontier, $\alpha + \beta \ln Q_i + \sum_{j=1}^{n} \delta_j \ln P_{ij} + V_i$. It is, therefore, one-sided as opposed to being symmetrically distributed about the origin. In other words, $U_i = 0$ if costs are, ceteris paribus, as low as can be, and $U_i > 0$ if cost efficiency is imperfect. U_i is assumed to be identically and independently distributed as truncations (at 0) of the normal distribution $N(\mu, \sigma_U^2)$. The stochastic cost function (1), may be estimated by maximum-likelihood. Given the above distributional assumptions,

$$E(U_i/\varepsilon_i) = \frac{\sigma\lambda}{(1+\lambda^2)}\left[\frac{\phi(\mu_i^*)}{1-\Phi(\mu_i^*)} - \mu_i^*\right] \tag{3}$$

where ϕ and Φ denote, respectively, the standard normal p.d.f. and the standard normal c.d.f., $\lambda = \sigma_U/\sigma_V$, $\sigma = \sqrt{\sigma_U^2 + \sigma_V^2}$, and $\mu_i^* = (\varepsilon_i\lambda/\sigma) + (\mu/\sigma\lambda)$. Replacing ε_i in the above expression by the regression residual and the other parameters by their ML estimates yields an estimate, $\hat{U}_i$, of farm-specific cost inefficiency (Jondrow et al., 1982).

Next, the equation,

$$\hat{U}_i = A_i\gamma_1 + L_i\gamma_2 + X_i\gamma_3 + e_i \tag{4}$$

is estimated by OLS, where A_i denotes household i's tobacco acreage, L_i represents the household's access to credit from formal sources measured as the sum of its members' self reported credit limits, variables X_i consist of other farm and household characteristics, and e_i denotes the regression error. In order to examine whether the effect of tobacco plot size on cost inefficiency is influenced by credit access, the equation,

$$\hat{U}_i = A_i\pi_1 + A_iL_i\pi_2 + L_i\pi_3 + X_i\pi_4 + e_i \tag{5}$$

is also estimated. Statistical significance of the interaction between tobacco acreage and credit access, A_iL_i, will yield the conclusion that access to credit influences the marginal effect of tobacco acreage on cost inefficiency.

The above two-stage method, consisting of ML estimation of a stochastic cost frontier followed by OLS estimation of an equation relating predicted cost inefficiency to the potential determinants of cost inefficiency, has lately been criticised. For one, a regression model of predicted inefficiency effects in Stage 2 contradicts the assumption in Stage 1 of identically distributed inefficiency effects (Battese and Coelli, 1995). Hence, the twin steps are alternatively combined into a single step according the model by Battese and Coelli (1995). It is continued to be assumed that V_i, random variation in cost per acre due to extraneous factors such as the weather, is independently and identically distributed as $N(0, \sigma_V^2)$. However, U_i, the cost inefficiency component, is now assumed to be independently, but not identically, distributed as truncations (at 0) of the normal distribution $N(Z_i\theta, \sigma_U)$. In other words, the mean of the cost inefficiency effect is assumed to be a function of variables Z_i, taken in the empirical estimation, to be identical to the regressors in (5). This specification permits the coefficients θ to be estimated together with the coefficients of the cost frontier (1).

4. The data and empirical results

Data for the study are drawn from the Malawi Financial Markets and Household Food Security Survey conducted jointly in 1995 by the International Food Policy Research Institute (IFPRI) and the Department of Rural Development (DRP) of the Bunda College of Agriculture of the University of Malawi. A total of 404 rural households in 45 villages in five districts of Malawi were surveyed. The yearlong survey (from February to December) consisted of three rounds. The empirical analyses are conducted upon data from the second round of the survey, since only it contained the requisite detailed tobacco production data. While rarely in household surveys is labour input disaggregated by crop, these data permit the valuation of labour expended in tobacco cultivation alone towards calculation of the cost per acre of tobacco production.

There are four main credit and savings programs currently operating in Malawi: the Malawi Rural Finance Company (MRFC), Promotion of Micro-Enterprises for Rural Women (PMERW), the Malawi Mudzi Fund (MMF), and the Malawi Union

of Savings and Credit Co-operatives (MUSCCO). The first three programs are based on the principles of group lending, while MUSCCO is an individual membership based union organisation. MRFC and MUSCCO provide seasonal agricultural credit, mostly for tobacco and maize, though the former does not serve households with less than half a hectare of land. PMERW and MMF, operating in only a few districts, specialise in credit for off-farm enterprises. There are, in addition, numerous small credit programs run by NGOs and international government organisations.

The above 404 rural households do not constitute a random sample. Since it was necessary to include sufficient numbers of credit program participants in the survey, the low participation rate in credit programs in Malawi made random sampling impractical. Hence, the surveyors resorted to stratified random sampling. The 4700 rural households enumerated in the 45 villages covered by the Malawi village census were divided into three strata: a stratum consisting of current participants in the above four credit programs, a stratum consisting of past participants (mostly in a failed government credit program), and a stratum consisting of households that had never participated in a credit program. A random sample was chosen from each stratum such that about half of the final sample of 404 households consisted of current credit program participants, with past participants and non-participants making up approximately equal portions of the remainder. Thus, the survey over samples current credit program participants. The empirical estimation incorporates sampling weights in an attempt to account for this over sampling.

In each round of the Malawi Financial Markets and Household Food Security Survey, respondents over 17 years old were queried about the maximum amount they might conceivably have borrowed during the period of recall. A household's access to credit from formal sources may, thus, be calculated as the sum of the credit limits of its members at credit organisations.

The cost per acre of tobacco production is measured as the sum of the costs of seed, fertiliser, pesticide, and labour input, and the costs of transporting inputs to the farm and transporting the crop to market. The inputs whose log prices are included in the specification of the stochastic cost function (1), are: labour, seed, fertiliser, and pesticide. Farm and household characteristics with plausible bearing upon cost inefficiency, the variables X_i in (4) and (5), include the value of farm assets, farm size, household size, the average age of 12-year-old or older family members, the proportion of family members aged 12 and above able to read and write Chichewa, the proportion able to read and write English, and the proportions with the educational credentials: Primary School Leaving Certificate (Grade 8), Junior Certificate (Grade 10), and M.S.C.E. certificate (Grade 12). Relevant data were available for 70 tobacco cultivating households. However, it was discovered that tobacco acreage erroneously exceeded farm size in three of these households, no doubt, due to coding error. The three households were dropped, yielding a final sample of 67 households. Table 1 presents the (unweighted) sample means and standard deviations of the variables.

Table 2 presents weighted maximum-likelihood[3] estimates of the stochastic cost frontier. The cost per acre of producing tobacco significantly increases in the value of output per acre, in the hourly wage, in the price per kilogram of tobacco seed, and in the price per kilogram of fertiliser. Cost, however, appears to decrease in the cost per kilogram of pesticide.

Table 3 presents weighted OLS estimates of (4) and (5). It is assumed that tobacco acreage is an exogenous regressor, or that farmers first allocate land between tobacco and other crops and only subsequently make their tobacco inputs application decisions. This is a plausible assumption in the Malawian context. The average cropping share of tobacco in Malawian smallholdings is only about 2% (Diagne and Zeller, 2001). Diagne and Zeller (2001) argue that this small cropping share is due to smallholders' desire for self-sufficiency in maize, the Malawian dietary staple. It is significant in this context that 90% of Malawian smallholders in a study by Smale and Phiri (1998) declared that the ability to produce maize for self-consumption was their most important criterion of well being. Diagne and Zeller (2001) argue that such self-sufficiency may be necessary in the face of the malfunctioning of rural maize markets, caused by a lack of marketable surplus of maize in smallholdings and an inadequate transportation infrastructure. Thus,

[3] The weighted log-likelihood function is simply the sum over all i of $w_i \log(p_i)$, where w_i is the sampling weight associated with the ith tobacco farming household and p_i is the ith log probability.

Table 1
Sample means and standard deviations (unweighted)

Variable	Mean	Standard deviation
ln(cost of producing tobacco per acre)	6.815	0.927
ln(value of tobacco production per acre)	7.529	1.278
ln(hourly wage)	−0.770	0.946
ln(price of seed/kg)	7.158	0.499
ln(price of fertiliser/kg)	0.678	0.184
ln(price of pesticide/kg)	4.769	1.407
Household credit limit at formal credit institutions	278.508	540.351
Tobacco acreage	1.612	1.314
Household credit limit at formal credit institutions × tobacco acreage	738.209	2770.504
Farm acreage	4.809	2.617
Value of farm assets	740.731	1232.080
Household size	6.328	2.338
Average age of +12-year-old household members	30.453	8.762
Proportion of +12-year-old household members literate in Chichewa	0.282	0.319
Proportion of +12-year-old household members literate in English	0.161	0.225
Proportion of +12-year-old household members with Primary School Leaving Certificate	0.147	0.209
Proportion of +12-year-old household members with Junior Certificate	0.030	0.100
Proportion of +12-year-old household members with M.S.C.E. certificate	0.014	0.059
N	67	

Note: All monetary values are in current Malawi Kwacha (MK).

it is credible that smallholders' food security concerns lead them to first allocate the bulk of their land to maize, leaving but little for tobacco, and only then to make their tobacco inputs application decisions.

It is found that cost inefficiency per acre significantly decreases in tobacco acreage. This suggests that the government's policy of promoting tobacco cultivation in smallholdings as opposed to tobacco estates has made production of this premier cash crop more cost inefficient, even if it has promoted equity in the rural economy. An inverse relation between cost inefficiency and tobacco plot size is consistent with Diagne and Zeller's (2001) finding that Malawian smallholders, particularly those farming plots of a total size of <0.25 ha (0.62 acres), are prone to applying excessive quantities of inputs, particularly fertiliser. The authors argue that farmers may be attempting to compensate for the scarcity of land by the over-use of inputs, and that this may be particularly true in tobacco farming since the crop is allocated only about 2% of the average 0.7 ha (1.73 acres) of land cultivated by a smallholder. Thus, increase in tobacco acreage may reduce this compensatory over-use of inputs, causing a decline in cost inefficiency per acre. This has the important implication that if the mean cropping share of tobacco in smallholdings were, by a combination of incentives, raised from its current low value of 2%, average cost efficiency in smallholder tobacco production would rise. Since a likely reason for this low cropping share is smallholders' desire for self-sufficiency in maize, with roots in the poor functioning of rural maize markets, tobacco's cropping share in smallholdings might increase if the government improved the functioning of rural maize markets, e.g. by upgrading the rural transportation infrastructure.

The estimates in Table 3 also indicate that a tobacco farming household's credit limit at credit organisations

Table 2
Weighted ML estimates of the stochastic cost frontier

Variable	Coefficient
Constant	0.434 (0.435)
ln(value of tobacco production per acre)	0.409 (10.470)
ln(hourly wage)	0.483 (7.726)
ln(price of seed/kg)	0.353 (2.337)
ln(price of fertiliser/kg)	1.297 (5.873)
ln(price of pesticide/kg)	−0.113 (−1.859)
log-likelihood	−43.514

Note: Numbers in parentheses denote *t*-ratios.

Table 3
Determinants of cost inefficiency: weighted OLS estimates

Variable	Coefficients Eq. (4)	Coefficients Eq. (5)
Constant	−0.560 (−1.696)	−0.440 (−1.369)
Household credit limit at formal credit institutions	0.0002 (1.025)	−0.0002 (−0.962)
Tobacco acreage	−0.283 (−3.215)	−0.400 (−4.085)
Household credit limit at formal credit institutions × tobacco acreage		0.0001 (2.369)
Value of farm assets	0.00004 (0.491)	0.00002 (0.226)
Farm acreage	0.074 (2.390)	0.078 (2.637)
Household size	0.089 (3.035)	0.093 (3.289)
Average age of +12-year-old household members	0.029 (3.643)	0.030 (3.898)
Proportion of +12-year-old household members literate in Chichewa	−0.574 (−2.288)	−0.616 (−2.550)
Proportion of +12-year-old household members literate in English	1.016 (2.911)	1.058 (3.151)
Proportion of +12-year-old household members with Primary School Leaving Certificate	−0.073 (−0.189)	−0.208 (−0.555)
Proportion of +12-year-old household members with Junior Certificate	−0.026 (−0.027)	0.053 (0.058)
Proportion of +12-year-old household members with M.S.C.E. certificate	−1.190 (−1.006)	−1.148 (−1.009)
R^2	0.608	0.645

Note: Numbers in parentheses denote *t*-ratios; dependent variable = estimated farm-specific cost inefficiency; weighted sample mean of dependent variable = 0.646.

does not by itself significantly affect cost inefficiency. However, the sign of the estimated coefficient of the interaction between tobacco acreage and credit access, together with the statistical significance of this variable, implies that the beneficial effect of a larger tobacco plot size on cost inefficiency is eroded by access to credit. Credit in Malawi is often disbursed in the form of agricultural inputs like fertiliser. The fertiliser packages are standardised for only a small number of plot sizes with the result that a farmer may be lent an excessive quantity of fertiliser (Diagne and Zeller, 2001). To the extent that a household's credit limit is correlated with its actual loan uptake,[4] this type of loan disbursement may contribute to the above negative effect of the credit limit upon the gain in cost efficiency from a larger tobacco plot size. In other words, the compensatory over-use of inputs may reduce with increased tobacco acreage, but a simultaneous increase in access to credit may contribute to persistence in farmers' excessive input application per tobacco acre.

There are a number of other findings of interest. For example, controlling for tobacco acreage, total farm acreage and cost inefficiency in tobacco production are positively related. Holding tobacco acreage constant, larger farms naturally have more land under crops other than tobacco, such as maize, the major Malawian food crop. To the extent that these crops require large applications of market inputs like fertiliser,[5] that farmers are resource strapped, and that market inputs are in relatively short supply, the quantities per acre of such inputs applied to tobacco may be inversely related to acreage under other crops. Allocative inefficiency in input application may result. For example, the reduced use of market inputs in tobacco may be accompanied by a compensatory over-application of non-market inputs such as household labour. Cost inefficiency per acre may consequently rise. It is notable in this connection that the estimates in Table 3 are indicative of a tendency toward the over-use of family labour on tobacco plots, in that cost inefficiency per acre increases in the number of household members. Similarly, an increase in the average age of household members older than 11, consistent with a rise in the number of members of working age, raises cost inefficiency per acre in tobacco cultivation. There is indication that cost inefficiency is inversely related to household human capital measured as the proportion of household members older than 11 who are literate in Chichewa, the local language. It is puzzling, however, that cost inefficiency significantly increases in the proportion literate

[4] Sample correlation between the household credit limit and actual loan uptake is 0.764.

[5] Hybrid maize, for instance, requires large and timely fertiliser applications.

in English. Perhaps non-farm earnings opportunities increase in English literacy so that households with a greater proportion of members literate in English are less reliant upon farm incomes and, therefore, more prone to inefficiency in tobacco cultivation.

Table 4 presents joint ML estimates of the stochastic cost frontier and the determinants of mean cost inefficiency, pertaining to the stochastic frontier model by Battese and Coelli (1995). Unfortunately, sampling weights could not be incorporated in the estimation given the limitations of the Fortran program (Frontier Version 4.1) developed by these authors. Hence, the point estimates in Table 4 are often markedly different from those in Tables 2 and 3 even if they are indicative of the same broad trends. The cost per acre of tobacco production significantly increases in the value of tobacco output per acre, in the hourly wage rate, in the price per kilogram of seed and in the price per kilogram of fertiliser. As before, cost appears negatively related to the price per kilogram of pesticide though the variable not statistically significant by these unweighted estimates. Mean cost inefficiency appears negatively and significantly related to tobacco plot size, and, as before, there is indication that the gain in cost efficiency from a larger plot size is reduced by access to credit, though credit access by itself has no statistically discernible effect on mean cost inefficiency. In sum, the major findings in Table 3 are upheld.

The above findings may be contrasted with the results from two other studies relating efficiency in agricultural production, measured within the framework of stochastic frontier analysis, to credit availability and plot size. Parikh et al. (1995) examine the determinants of cost inefficiency, including credit availability and farm size, in Pakistani agriculture. Credit availability is defined as actual loan uptake per farm acre. The authors find that farmers with greater loan uptake are less cost inefficient. However, since this measure of credit access is potentially endogenous as discussed, the above finding may not be relied upon. The authors also find that cost inefficiency increases in farm size. Note, though, that the authors aggregate across at least four crops, namely, wheat, maize, sugarcane, and vegetables. This study, on the other hand, focuses upon a

Table 4
The stochastic cost frontier and determinants of mean cost inefficiency estimated jointly: unweighted ML estimates

Variable	Coefficient
Estimates of the stochastic cost frontier	
Constant	1.216 (1.636)
ln(value of tobacco production Per acre)	0.328 (6.058)
ln(hourly wage)	0.518 (5.137)
ln(price of seed/kg)	0.257 (2.342)
ln(price of fertiliser/kg)	1.327 (3.581)
ln(price of pesticide/kg)	−0.032 (−0.466)
Determinants of mean cost inefficiency	
Constant	0.610 (0.726)
Household credit limit at formal credit institutions	0.00007 (0.194)
Tobacco acreage	−0.722 (−2.073)
Household credit limit at formal credit institutions × tobacco acreage	0.0002 (1.684)
Value of farm assets	−0.00005 (−0.286)
Farm acreage	0.058 (0.972)
Household size	0.038 (0.708)
Average age of +12-year-old household members	0.019 (1.220)
Proportion of +12-year-old household members literate in Chichewa	−0.346 (−0.673)
Proportion of +12-year-old household members literate in English	0.752 (1.264)
Proportion of +12-year-old household members with Primary School Leaving Certificate	−0.391 (−0.563)
Proportion of +12-year-old household members with Junior Certificate	−0.227 (−0.189)
Proportion of +12-year-old household members with M.S.C.E. certificate	−0.092 (−0.037)
log-likelihood	49.247

Note: Numbers in parentheses denote *t*-ratios.

single crop. Therefore, the finding that Malawian tobacco cultivation is less cost inefficient in larger plots may not be directly compared with the above finding that cost inefficiency in Pakistani agriculture increases in holding size.

Ali and Flinn (1989) examine profit, not cost, efficiency among basmati rice producers in the Punjab province of Pakistan. Still, there are similarities between the notions of cost efficiency and profit efficiency in that both arise from technical as well as allocative efficiency. Farmers, in this study, were asked if a lack of credit hampered their purchase of fertiliser. Hence, a dichotomous indicator of credit non-availability measures access to credit. Credit non-availability was positively and significantly related to profit inefficiency. Since a farmer citing credit non-availability is one who has attempted to borrow, this measure of credit access is, like actual loan uptake, potentially endogenous. The authors also find that profit inefficiency increases in farm size, though not significantly so.

5. Conclusion

The promotion of tobacco cultivation is a key component of the Malawian strategy of smallholder-led growth. Given the substantial capital requirements of tobacco farming, improving farmers' access to credit may be necessary toward achieving more widespread burley tobacco production. Indeed, there is evidence of positive correlation between access to credit and the cropping share of tobacco in smallholdings (Zeller et al., 1997). However, this paper finds no evidence of a positive relation between access to credit from formal sources and efficiency in tobacco farming. Thus, improving farmers' access to credit in Malawi will likely promote tobacco cultivation only along the extensive margin.

Unlike most analyses of the effects of credit, this paper measures household access to credit from formal sources as the sum of members' self-reported credit limits at credit organisations. It has previously been argued that the credit limit is a truer measure of an exogenous credit constraint since it reflects mostly supply-side factors such as the availability of credit programs and the financial resources of lenders (Diagne, 1998; Diagne and Zeller, 2001).

The paper also finds that tobacco cultivation is less cost inefficient on larger plots. This may be taken as indicative of an equity-efficiency trade-off in the Malawian tobacco sector. The finding suggests that the Government of Malawi's policy of encouraging tobacco production by smallholders as opposed to supporting the erstwhile monopoly of the tobacco estates, has led to declining cost efficiency in the production of this premier cash crop, even if it has promoted equity in the rural economy. It also suggests that increasing the cropping share of tobacco in smallholdings from its current low levels will tend to raise the economic efficiency of tobacco production.

The paper also uncovers evidence that access to credit retards the gain in cost efficiency from an increase in tobacco acreage. This suggests that the methods of credit disbursement in rural Malawi are faulty. Indeed, faulty credit disbursement mechanisms may partially explain why access to credit by itself, despite its potential benefits, has no statistically discernible effect on cost inefficiency.

Our findings have two broad policy implications. As argued, an increase in the cropping share of tobacco in smallholdings may reduce cost inefficiency in the production of this crop. Therefore, policies that rid farmers of their tendency to allocate the bulk of their landholdings to maize may raise efficiency in tobacco production. Such policies may include efforts to improve the functioning of rural maize markets so as to reduce the need for self-sufficiency in maize. Next, credit disbursement mechanisms in Malawi may require a degree of reform. It ought to be ensured that farmers are not lent excessive quantities of costly inputs. Tobacco is an extremely important cash crop to the Malawian economy and it is advisable that the Government of Malawi vigorously pursue policies to raise economic efficiency in its production.

Uncited references

Diagne et al. (1995), CIMMYT (1998).

Acknowledgements

Helpful comments from Winford Masanjala are gratefully acknowledged.

References

Aigner, D., Knox Lovell, C.A., Schmidt, P., 1977. Formulation and estimation of stochastic frontier production function models. J. Econometrics 6, 21–37.

Ali, M., Flinn, J.C., 1989. Profit efficiency among basmati rice producers in Pakistan Punjab. Am. J. Agric. Econ. 71, 303–310.

Battese, G.E., Coelli, T.J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empirical Econ. 20, 325–332.

CIMMYT Economics Working Paper 1998–2001, Centro Internacional de Mejormiento de Maiz y Trigo (CIMMYT), Mexico city.

David, C., Meyer, W., 1980. Measuring the farm level impact of agricultural loans in low income countries: a review article. In: Howell, J. (Ed.), Borrowers and Lenders: Rural Financial Markets and Institutions in Developing Countries. Overseas Development Institute, London.

Diagne, A., 1998. Impact of Access to Credit on Income and Food Security in Malawi. IFPRI FCND Discussion Paper No. 46, International Food Policy Research Institute (IFPRI), Washington, DC.

Diagne, A., Zeller, M., 2001. Access to Credit and its Impact on Welfare in Malawi. IFPRI Research Report No. 116, International Food Policy Research Institute (IFPRI), Washington, DC.

Diagne, A., Zeller, M., Mataya, C., 1995. Rural Financial Markets and Household Food Security: Impacts of Access to Credit on the Socio-Economic Situation of Rural Households in Malawi. Interim Report Submitted to the Ministry of Women, Children Affairs, Community Services and Social Welfare (MOWCACSSW) and Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) in Malawi.

Feder, G., Lau, L.J., Lin, J.Y., Luo, X., 1990. The relationship between credit and productivity in Chinese agriculture: a microeconomic model of disequilibrium. Am. J. Agric. Econ. 72, 1151–1157.

Jondrow, J., Knox Lovell, C.A., Materov, I.S., Schmidt, P., 1982. On the estimation of technical efficiency in the stochastic frontier production function. J. Econometrics 19, 233–238.

Parikh, A., Ali, F., Shah, M.K., 1995. Measurement of economic efficiency in Pakistani agriculture. Am. J. Agric. Econ. 77, 675–685.

Smale, M., Phiri, A., 1998. Institutional Change and Discontinuities in Farmers' Use of Hybrid Maize in Malawi: Findings From the 1996–1997 CIMMYT/MoALD.

Zeller, M., Ahmed, A., Babu, S., Broca, S., Diagne, A., Sharma, M., 1996. Rural Financial Policies for Food Security of the Poor: Methodologies for a Multi-Country Research Project. IFPRI FCND Discussion Paper No. 11, International Food Policy Research Institute (IFPRI), Washington, DC.

Zeller, M., Diagne, A., Mataya, C., 1997. Market Access by Smallholder Farmers in Malawi: Implications for Technology Adoption, Agricultural Productivity, and Crop Income. IFPRI FCND Discussion Paper No. 35, International Food Policy Research Institute (IFPRI), Washington, DC.

World Bank, 1995. Malawi's Human Resources and Poverty: Profiles and Priorities for Action. Southern Africa Department, The World Bank, Washington, DC.

World Bank, 2000. World Development Report. The World Bank, Washington, DC.