The Impact of credit constraints on the adoption of hybrid maize in Malawi

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Abstract

The paper investigates the impact of credit constraints on the adoption of hybrid maize among rural households in Malawi using the treatment-effects model. Results reveal that after effectively correcting for endogeneity, credit constraints have a reducing effect on the size of land allocated to hybrid maize. Farmers with larger land holdings allocate more land to hybrid maize while older farmers allocate less land to hybrid maize. These findings suggest that there is scope for increasing the cultivation of hybrid maize in Malawi if credit is targeted at younger farmers that are credit-constrained.

Keywords: credit constraints, hybrid maize, adoption, treatment- effect, endogenous, Malawi

1.0 Introduction

Crop productivity improvement through the use of modern varieties such as hybrid maize is popularly believed to offer hope for a green revolution in the developing countries. Consistent with this notion, some authors argue that the maize Green Revolution occurred in some Eastern and Southern African countries such as in Zimbabwe (Eicher, 1997) and in Kenya (Hassan et al., 1998b; Karanja, 1993) after decolonization, but it fizzled in the mid 1980s. Carr (1997), in his paper "a Green revolution frustrated", observes that Malawi briefly experienced a green revolution in the early 1990s when the use of fertilizer and hybrid seed had been adopted on almost half of the total maize area. Yields of fertilized hybrid maize had increased to about three times those obtained under traditional practices, which led a number of international observers to classify Malawi's experience as an example of an African "Green Revolution".

However, due to a number of policy changes, including changes in subsidy policy, liberalization of input and output markets, and the floating of the currency, among others, farmers could not afford to purchase hybrid maize seed and fertilizer. In 1995/96 season, for example, smallholder farmers were only able to purchase hybrid maize seed sufficient to plant 7% of the maize area. Local maize has a flint grain texture, highly valued by Malawian smallholders because of the higher flour-to-grain extraction rate.

Recognizing the potential contribution of credit in enhancing the adoption of hybrid maize among smallholders, the government of Malawi pursued a credit policy aimed at promoting hybrid maize production from the early 1980s through to the 1990s. The government of Malawi started providing joint liability loans to smallholder farmers as far back as 1973 through the Smallholder Agricultural Credit Administration (SACA), three years before the Grameen Bank was created (Diagne, *et al.,* 2000). The main purpose of the credit was to promote smallholders' production of high value crops (first maize, then later in the 1990s also tobacco, with hardly any loans for hybrid maize seed from the late 1990s unless tied to tobacco loans). The credit was mainly provided to farmers in the form of in-kind loans such as fertilizer and seed. However, despite concerted efforts by the government and more recently non-governmental organizations in promoting the cultivation of hybrid maize, the adoption rate remains low and in 2003, more than half of the total maize land was allocated to local varieties (GOM, 2004). In 2003 an upward trend in the hybrid area was noted and again in 2006, which have been associated with an increase in the supply of subsidized seed.

A substantial amount of the literature has reported on the impact of access to credit on adoption, and there is considerable research showing the positive impact of credit on adoption. For, example, Feder and Umali (1993) and Cornejo and McBrid (2002) review factors that affect technology adoption and highlight access to credit as a key determinant of adoption of most agricultural innovations. Nevertheless, most studies that have looked at the impact of credit have generalized their analysis by assuming that credit access should always lead to positive impact outcomes. In reality, however, there are circumstances in which access to credit may have no impact on household welfare. Credit access will only be effective for the credit "constrained" – those with access to remunerative consumption, production and investment opportunities who are unable to pursue the opportunities for lack of financial resources. A lack of access to credit may not necessarily imply an unmet credit need (*de* Janvry et al 1997). In the same way, the marginal contribution of credit is likely to be high in households that have a larger binding credit constraint than in those that are less constrained. In Malawi, as elsewhere, most adoption studies have not taken into account the credit constraint status of a household and those that attempted to do so did not adequately control for endogeneity.

Thus this paper aims to fill that gap by investigating the extent to which credit constraints have impeded the smallholder farmer's adoption of hybrid maize in Malawi. The study is pertinent in that it attempts to address two related questions: (i) "Who is credit constrained? And (ii) "Can credit constraints explain the non-adoption puzzle for hybrid maize?". The findings of the study can be used as an input to a process of credit policy improvement as well as understanding how best to use credit as a tool for enhancing the cultivation of hybrid maize.

Adopters of hybrid maize are defined as households that planted first generation hybrid seed[1] as opposed to recycled hybrid seed. The study uses a treatment effects model. The treatment effects model is particularly appropriate for this kind of analysis due to the presumption that credit constraints are endogenous in the adoption model. Using the direct elicitation approach proposed by Jappelli (1990), Diagne, Zeller and Sharma (2000) and Sawada et al. (2006), households are classified into credit constrained and unconstrained regimes. The treatment effects approach combines the estimation of the probability of being credit constrained as well as the estimation of the impact of credit constraints on the adoption of hybrid maize. Data used in this study is from Malawi collected by the International Food Policy Research Institute (IFPRI) in 1994. Results show that due to endogeneity of the credit constraint status of a household, the use of Ordinary Least Square and the Tobit estimates does not provide consistent estimates. Instead, we find that the treatment effects model that controls for the endogeneity of the credit constraints provides reliable estimates that reveal that credit constraints reduce the amount of land allocated to hybrid maize. The paper is organized as follows: In section two we present the empirical framework and an econometric specification of the empirical model. The data used for the estimation is described in section three. In section four we present and discuss results, while section 5is the conclusion.

[1] During the survey an attempt was made to ascertain whether or not the seed used was first generation. Other studies have shown that recycled hybrid maize produces low yield than local maize such that farmers are less likely to plant recycled hybrid maize

2. Theoretical framework and econometric specification of the empirical model

The analysis in the present paper is based on the hypothesis that credit constraints are a barrier to the adoption of improved technologies by most poor households. We start by presenting a framework of household consumption and credit constraints and then apply it to the adoption of hybrid maize. Following Diagne and Zeller (2001), Jappelli (1990), and Sawada et al. (2006), we construct a qualitative response model of endogenous credit constraint by defining an indicator variable of credit constraints cc. We do so by assuming that a household consumes some amount of goods, C, in a given period of time. Let C^* represent the optimal consumption in the absence of credit constraints. $C^* = C$ (the actual consumption) if the credit constraint is not binding; $C^* > C$ if the credit constraint is binding. The gap between optimal consumption and the actual consumption measures the existence or not of a credit constraint. We assume that the consumption gap is defined as $H^* = C - C^*$. According to Jappelli (1990), Sawada et al. (2006) and Gilligan et al. (2005), there are two factors that determine whether or not a household will face credit constraints. The first factor is the demand for credit which is the difference between household resource endowment and desired consumption. The second factor relates to the supply of credit by financial institutions. The optimal consumption C^* and the maximum available credit to the household can both be expressed as a linear function of observables such as the household's human and physical capital. A reduced form equation of the consumption gap can thus be written as follows:

$$H^* = w\gamma + \mu \qquad (1)$$

$$cc = \begin{cases} 1 \; if & H^* < 0 \\ 0 \; if & H^* \geq 0 \end{cases}$$

Where:

w represents household and farm characteristics that determine credit demand as well as the supply of credit to the household.

μ is a random error term with zero mean.

A household is said to have a binding credit constraint if H*<0 and thus cc=1. The credit constraint is not binding if $H^* \geq 0$ and thus $cc = 0$

The econometric model of the impact of credit constrains on the adoption of hybrid maize can be composed of two interrelated dependent variable models. The first model is a credit constraint equation (equation 1).
The second model relates to the adoption of hybrid maize in which the endogenous credit constraint status of a household is included as an explanatory variable as in the following equation:

$$y = \alpha cc + x_M \beta_M + \varepsilon \qquad (2)$$

Where, y is the household's land allocated to hybrid maize in each reference season, x_M is a matrix of household specific socioeconomic and demographic characteristics that affect adoption decisions. The variable cc is an indicator of credit constraints which takes the value of one if the credit constraint is binding and zero otherwise and is assumed to have a negative effect of hybrid maize adoption. The last term ε, is the error. Where (μ, ε) has zero mean, bivariate normal distribution with a unit variance and $\rho_1 = Corr(\mu, \varepsilon)$. The covariate matrix is written as follows:

$$\begin{bmatrix} \sigma & \rho \\ \rho & 1 \end{bmatrix}$$

Green (2000) notes that if $\rho_1 \neq 0$, then μ and ε are correlated, and that an estimation of equation (2) is inconsistent for α and β.

We observe that hybrid maize is a relatively old technology in Malawi and that most farmers are aware of the technology. Therefore the estimation of the adoption rates and its determinants is less likely to suffer from what Diagne and Demont (2007) call "*non exposure*" bias and from "*selection" bias* which results into inconsistent estimates if the bias is not corrected.

To estimate the model of the impact of credit constraints on the adoption of hybrid maize, we use the treatment effects model which estimates the effect of an endogenous binary treatment cc on a continuous, fully observed variable y , conditional on the independent variables x and w . The primary interest is in the regression function (equation 2). In the proposed treatment model, cc is the endogenous dummy variable indicating whether the treatment is assigned or not. The binary outcome treatment cc is modeled as the outcome of an unobserved latent variable cc^*. It is assumed that cc^* is a linear function of the exogenous covariate w and a random component u .

4.0 Data

In this paper we use the data collected by the International Food Policy Research Institute (IFPRI) in collaboration with Bunda College in Malawi in 1994 which contains the necessary information needed to identify credit-constrained households as well as those that adopted hybrid maize. The IFPRI Survey was designed to investigate the effects of access to credit on household welfare. The survey covered households from five districts of Rumphi, Nkhotakota, Dowa and Dedza and Mangochi. The four microcredit programs the survey focused upon included the Malawi Rural Finance Company (MRFC), a state-owned and nationwide agricultural credit program; Promotion of Micro-Enterprises for Rural Women (PMERW), a microcredit program targeted at women in support of nonfarm income-generating activities; the Malawi Mudzi Fund (MMF), a replica of the Grameen Bank; and the Malawi Union of Savings and Credit Cooperatives (MUSCCO), a union of locally based savings and credit associations. The IFPRI survey focused on these four microfinance institutions as representative of the spectrum of formal credit and savings options available to rural households in Malawi. The sample included 404 households of which half were members of credit programs and the other half were non-members.

In the IFPRI survey, respondents were asked whether or not they had tried to borrow from a formal lender in the past 12 months. Those who asked for loans were asked the amount they received and whether they received the full amount demanded. Those that had not attempted to borrow were asked why not. More precisely, the questions were as follows:

1a Did any member in your household apply for a loan from a formal institution in the last 12 months? Yes/no

1b If household applied, was the loan granted? Yes/no

1c If loan was granted was the household granted the same amount the loan as requested? Yes/no

2 If household members had not attempted to borrow, give reasons. The choices for the answers were as follows;

1= I did not need credit;

2=I dislike any borrowing

3= The loans are too expensive

4= I would have liked to apply for a loan but did not apply because I felt that lender would not give me a loan because of my age

5= I would have liked to apply for a loan but did not apply because I felt that lender would not give me a loan because of my health problems

6= I would have liked to apply for a loan but did not apply because I felt that lender would not give me a loan for other reasons other than age and health problems

7=Others

Respondents who chose any of the options 3, 4, 5 and 6 as reasons for not attempting to get a loan from a formal institution (question 2) are categorized as discouraged borrowers. Consistent with the credit literature, these respondents are included with those households that did not receive as much credit as requested from the formal lender and classified as credit constrained. About 43 percent of the surveyed households were classified as credit constrained.

Table 1 presents household characteristics divided by credit constraint status. Unconstrained households have relatively larger households (6.1 persons) than constrained households (5.4 persons). Results further show that unconstrained households are wealthier with an average household asset value of MK 4168 compared to MK 3293 for the credit constrained (at the time of the survey, 1 US Dollar was worth 44 Malawi Kwachas) Unconstrained households have a much smaller proportion of female-headed households (21%) than households that have some credit binding constraint (30%) suggesting that credit constraints in Malawi could be associated with the gender of household head. Unconstrained households have larger

land holdings (2.47 hectares) than constrained households (1.8 hectares). There are no marked differences in terms of age or years of education of the head of household.

5.0 Results and discussions

Table 2 presents the results on determinants of adoption under credit constraints. Three types of estimations are conducted to illustrate the importance of correcting for endogeneity when assessing the impact of credit constraints. In addition to credit constraints variables, we include other variables theoretically linked to technology adoption. Columns 1 and 2 present estimates of the adoption models estimated through Ordinary Least Squares (OLS) and Tobit regressions respectively, without correcting for the endogenous credit constraint status of a household.

What is first striking in the results presented in Table 2 is the poor performance of the simple OLS and Tobit regressions. The credit constraints variable has an unexpected positive sign and is not significant. The unexpected findings could, however, be attributed to the endogenous credit constraints. Other variables that returned positive and significant signs in the first two models include the land holding size and household wealth. The value of assets which was used as a proxy for household wealth had a positive and significant effect on the amount of land allocated to hybrid maize suggesting that richer households with a higher value of assets (household wealth) allocate more land to hybrid maize cultivation.

The results from the treatment effects model which corrects for the endogenous credit constraints are presented in columns 3 and 4. Column 3 presents estimates of the adoption equation while column 4 presents estimates of the credit constraint equation. One of the parameters of interest, the rho or ρ which measure the correlation between the errors in the credit constraint equation (equation1) and the reduced-form adoption equation (equation 2) is 0.834 and significantly different from zero (Chi square=0.0000). These findings suggest that the variable (credit constraint) is endogenous and thus we cannot reject the null hypothesis for no endogeneity of the credit constraint status of a household. Results further indicate that credit constraints have a negative and significant effect on the amount of land

allocated to hybrid maize. These findings indicate that being credit constrained reduces the amount of land cultivated under hybrid maize which is consistent with a priori expectations that due to credit constraints farmers are unable to purchase hybrid seed.

Other than credit constraints, a number of other variables returned significant coefficients. The age of the household head has a negative and significant effect on the adoption of hybrid maize. Age happens to be one of the human capital characteristics that have been frequently associated with non-adoption in most adoption studies. Among the several reasons that could explain the negative effect of age on adoption is the fact that older farmers tend to stick to their old production techniques and are usually less willing to accept change. In addition young people are associated with a higher risk-taking behavior than the elderly.

The land holding size returned a positive and significant coefficient indicating that household with larger land holdings allocated more land to hybrid maize. The result is consistent with a priori expectations in that it is widely hypothesized that the adoption of innovation tends to take place earlier on larger farms than on smaller farms. Consistent with this notion, Just, Zilberman and Rausser (1980) point out that given the uncertainty, and fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from adopting. A more plausible argument that relates to the situation in the Malawi could be related to what Feder et al. (1985) refer to as the problem of disentangling farm size from other factors hypothesized to influence technology adoption. They argue that farm size may be surrogate for other factors such as wealth, risk preferences, and access to information which also positively influence adoption.

The size of a household returned a positive but insignificant sign. The positive effect of household size on the on adoption can be explained by the fact that labor is an important input in the production of maize and therefore, larger households have abundant labor required for maize production. However the insignificant effect can be explained by the fact that the extent of adoption of hybrid maize (amount of land cultivated) is more likely to

depend on the ability of the household to finance the purchase of inputs such as seed and fertilizer required for the cultivation of hybrid maize, than the abundant household labor. This is particularly true because hybrid maize requires more capital for the purchase of fertilizer and seed than it requires labor because it is not labor intensive.

Free inputs have a positive but insignificant effect on hybrid maize implying that receiving free inputs encourages farmers to grow some hybrid maize but does not significantly increase the area of land allocated to hybrid maize. This can be explained as the amount of free inputs, distributed in form of fertilizer and seed, are usually the same across households and that they are usually only enough for the cultivation of about 0.25 acres. Thus although we expect free input to be significant in influencing the probability of growing hybrid maize, it is not important in influencing the amount of land under hybrid cultivation. The growing of tobacco had a reducing effect on the amount of land allocated to hybrid maize but its effect is not significant.

The results from a credit constraints equation (column 4) indicate that the value of household assets has a reducing effect on the likelihood of reporting credit constraints. Results indicate that households in the fifth quartile of the value of household non-agricultural assets are less likely to report credit constraints. The findings suggest that wealthier households in the third, fourth and fifth quartiles are less likely to face credit constraints. The probability of reporting credit constraints declines by about 5 percent in the fifth wealth category. This is consistent with prior expectations in that wealthier households are more likely able to self-finance which reduces their need for loans. The findings are also consistent with an observation made by Zeldes (1989) and Hayashi (1985) in which they report that constrained households are likely to have little wealth. The membership in credit programs also has a reducing effect on the likelihood of facing credit constraints suggesting that membership in credit programs allows members to meet their financial needs.

6.0 Conclusions

This study has examined the impact of credit constraints on the adoption of hybrid maize and demonstrated the importance of correcting for endogeneity when assessing the impact of credit constraints on technology adoption. This is done by comparing outcomes from OLS and the Tobit regressions with those from the treatment effects model with correction for endogenous credit constraints.

Credit constraints are found to have reducing effect on the amount of land allocated to hybrid maize. Results also indicate that factors that are seen to affect adoption under models that do not address endogeneity are different from those that influence adoption when credit constraints are treated as endogenous to the model. The fact that credit constraints have higher and negative impact on the cultivation of hybrid maize suggests that there is scope for increasing the cultivation of hybrid maize by increasing access to credit by credit-constrained households. The negative and significant impact of age of the farmer on the adoption of hybrid maize suggests that credit should be targeted at younger farmers that are credit constrained to enhance their cultivation of hybrid maize.

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Table 1: Household characteristics by credit constraint status

`	Unconstrained households (n=233)	Credit constrained households (n=171)	Total (n=404)
Age of head (years)	45.01	45.18	45.13
	(12.19)	(14.08)	(13.58)
Years of schooling of head	4.65	4.15	4.28
	(3.46)	(3.25)	(3.31)
Sex of head of household (1=male, 0=female)	0.79	0.70	0.72
	(0.41)	(0.46)	(0.45)
Population males 15 to 64 years	1.27	1.21	1.22
	(1.03)	(0.83)	(0.89)
Population females 15 to 64 years	1.48	1.47	1.47
	(0.77)	(0.83)	(0.81)
Household size	6.10	5.41	5.59
	(2.83)	(2.46)	(2.58)
Total hectares of household land	2.47	1.87	2.03
	(2.51)	(1.66)	(1.93)
Distance to Field assistant (kilometers)	2.75	2.04	2.23
	(3.91)	(3.48)	(3.61)
Values of household assets (Malawi Kwacha)	4168	3293	3527
	(12601)	(6794)	(8723)
Whether received free inputs from government (%)	15	18	16

Source: Own Calculations from Malawi-IFPRI Survey
* Figures in parenthesis are standard deviations

Table 2: Determinants of adoption under credit constraints

Variable	OLS regression	Tobit regression	Treatment regression with correction for endogeneity	
			Adoption	Credit constraints
Credit constraint	0.1109	0.1171	-2.0655***	
	(0.1458)	(0.2232)	(0.2291)	
Free input	0.0114	0.2861	0.0424	
	(0.1680)	(0.2455)	(0.1512)	
Age household head	-0.0079	-0.0113	-0.0157**	-0.0089*
	(0.0057)	(0.0089)	(0.0069)	(0.0051)
Education head	-0.0223	-0.0512	-0.0413	-0.0264
	(0.0269)	0.0405	(0.0330)	(0.0241)
Gender (1=male)	-0.0375	0.1263	-0.3010	
	(0.1637)	(0.2536)	(0.2010)	
Household size	0.0035	0.0489	0.0125	
	(0.0306)	(0.0466)	(0.0313)	

Quartile number 2 value of assets	0.4425*	1.0497***	0.1580	-0.2622
	(0.2290)	(0.3702)	(0.2819)	(0.2063)
Quartile number 3 value of assets	0.4408*	1.1277***	0.2130	-0.2025
	(0.2376)	(0.3702)	(0.2910)	(0.2118)
Quartile number 4 value of assets	0.5095**	1.1510***	0.4867	-0.0406
	(0.2434)	(0.3868)	(0.2987)	(0.2226)
Quartile number 5 value of assets	0.7707***	1.4754***	0.4023	-0.4121*
	(0.2615)	(0.4088)	(0.3211)	(0.2370)
Total land holding	0.6224***	0.7182***	0.6340***	0.0716
	(0.0400)	(0.0579)	(0.0491)	(0.0511)
Tobacco grower (yes-1, no=0	-.079694	0.06034	-0.2990	
	(0.19109)	0.29101	(0.184)	
Distance to the extension worker	0.0063	0.0090	-0.0027	
	(0.0232)	(0.0372)	(0.0220)	
Nkhota	-0.4950*	-1.0683**	-0.2912	0.1679
	(0.2717)	(0.4191)	(0.3302)	(0.3417)
Rumphi	-0.4634	-0.6453	-0.4454	-0.1955
	(0.2834)	(0.4260)	(0.3447)	(0.3457)
Dedza	-0.5575*	-1.1954***	-0.6879**	-0.1387
	(0.2437)	(0.3815)	(0.2971)	(0.2633)
Constant	0.2223	-1.0922*	1.8687***	0.6665*
	(0.4103)	(0.6489)	(0.5107)	(0.3671)
Number of females (15-64 years)				0.1496**
				(0.0699)
Member of MRFC				-0.4933***
				(0.1420)
Member of MUSCO				-0.8515***
				(0.2425)
/athrho [a]			1.1828***	
			(0.1240)	
/lnsigma		1.9744	0.5500***	
		(0.0956)	(0.0522)	
			0.8345***	
Rho			(0.0369)	
Sigma			1.7482 (0.0897)	
No. of obs	404	404	404	404

LR test of indep. Eqns. (rho = 0): chi2(1) = 39.93 Prob > chi2 = 0.0000

Source: Own calculation from RDD/IFPRI Rural Finance Survey

* ,**, ***. Significance at 10%, 5%, and 1 % level,

Figures in parenthesis are standard errors

[a] lnsigma and athrho are transformations of sigma and rho that are used in` the estimation process