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CREDIT CONSTRAINTS AND SMALLHOLDER DAIRY PRODUCTION IN THE EAST AFRICAN HIGHLANDS: APPLICATION OF A SWITCHING REGRESSION MODEL

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Abstract

Accurate assessment of farmers' credit constraint condition is important in order to understand the circumstances under which credit would have its greatest impact. In this study a switching regression model was used to determine the impact of credit on smallholder dairy farms in the East African highlands using farm level data from Ethiopia and Kenya. Farmers were classified as credit constrained or credit non-constrained based on their responses from the farm level surveys. No consistent relationship was found between farmers' credit constraint condition and their borrowing status. Most of the variation in milk output per farm was explained by the number of crossbred milking cows in the dairy herd. Because credit is likely to facilitate investment in crossbred dairy cows it will have substantial impacts on smallholder dairy farms especially if it is targeted to credit constrained farms.

Key words: Credit constrained, credit non-constrained, milk productivity, switching regression

1. Introduction

In peri-urban areas of the East African highlands strong urban demand driven by increasing urbanization and income growth is encouraging the development of smallholder dairying (ILCA, 1995). Several organizations including international and national agricultural research centers, The World Bank, ministries of agriculture, and non-governmental organizations have developed and promoted the use of improved dairy technologies to help increase farm productivity and smallholder income. Yet the rate of adoption of these technologies among smallholder farmers remain low (Freeman et al., 1998; Oluoch-Kosura and Ackello-Ogutu, 1998).

One likely explanation for low adoption rates of improved dairy technologies is that binding capital constraints limit the ability of many smallholder livestock farmers to make the initial investments or finance the variable costs associated with improved dairy technologies (Rey et. al., 1993). Economic theory suggests that farmers facing binding capital constraints would tend to use lower levels and combinations of inputs than those whose production activities are not limited by capital constraints. Access to credit can facilitate levels of input use closer to their potential levels when capital is not a constraint. Production loans from financial institutions can, therefore, lead to higher levels of output per farm and yield given fixed resources such as land. Policy makers and financial institutions however need to accurately assess the magnitude of the expected gains in productivity resulting from the allocation of agricultural credit. If the marginal contribution of credit to farm productivity is zero or relatively small then re-allocation of credit to other activities or sectors with higher marginal productivity may actually lead to an improvement in the welfare of society.

This study examines the impact of credit on milk productivity, defined as milk output per farm, on smallholder dairy farms in the East African highlands using data from Ethiopia and Kenya. These two countries provide useful insights into the potential for peri-urban dairy development in this region because of the growing importance of peri-urban dairy activities in these countries and their favorable climatic conditions which makes them ideal for dairy production (ILCA, 1995). To test the relationship between credit and milk productivity an approach is used which recognizes that disequilibrium may exist in household credit demand or credit supply. It is postulated that borrowers and non-borrowers are not homogeneous. For the purposes of this analysis, farmers were considered credit constrained if they already had a loan and yet expressed willingness to borrow more at current interest rates or they did not borrow because their request for a loan was not approved, there was no formal or informal lender to lend them, or they feared borrowing. Some farmers who reported that there were no lenders self selected themselves out of credit markets on the assumption that they are not eligible to borrow while those who reported that they feared borrowing were considered to be risk averse to borrowing.

2. Sources and use of credit by livestock farmers in Ethiopia and Kenya

Few studies have documented the supply of credit to smallholder livestock producers in sub-Saharan Africa. But the limited evidence suggests that formal financial institutions, such as commercial banks and cooperatives, play an essential role in the flow of credit to the livestock sector even though the policies and practices of these institutions frequently discriminate against smallholder producers (Freeman et. al., 1998). For example studies in Uganda, Ethiopia, and Nigeria show that collateral and minimum investment requirements as well as information problems restrict access to credit for smallholder livestock producers (Freeman et. al., 1998).

Livestock farmers in this study received credit from both formal and informal lenders. In the Ethiopia sample 48 percent of farmers reported receiving credit form both formal and informal sources. Of those who borrowed 64 percent had loans from commercial banks while 36 percent had loans from informal sources such as savings clubs, friends and relatives. Bank loans were usually given in cash with an average repayment period of six years payable in fixed installments. Most farmers who received bank loans were recommended by development agencies and service cooperatives.

Over two thirds of farmers who received bank loans were classified as credit non-constrained. These farmers tended to receive larger loans compared to credit constrained farmers. The average size of bank loans to credit non-constrained farmers was EB1151 while that to credit constrained farmers was EB 724 (1 US$ = EB 6.25 at the time of the survey). About 40 percent of credit constrained farmers reported that the amount of loan they received at the going interest rate was less than what they requested. In contrast only 10 percent of credit non-constrained farmers reported receiving a smaller amount of loan than they requested.

The most important use of formal credit farmers reported was purchase of dairy cows. Over 75 percent of farmers who received credit from commercial banks used loans to purchase crossbred dairy cows. Of these about 80 percent were classified as credit constrained.

In Kenya 38 percent of the farmers in the study reported receiving loans from formal and informal sources. Formal institutions such as commercial banks and cooperatives were the most important sources of credit. Of all borrowers 67 percent obtained loans through cooperatives and 20 percent through commercial banks. Cash loans accounted for over 90 percent of credit disbursed with an average duration of 3 years.

About half of the borrowers who received credit from formal sources were classified as credit constrained. Similar to the Ethiopian sample, credit non-constrained farmers reported receiving larger loans compared to credit constrained farmers. The average size of loan to credit non-constrained farmers was Ksh 23120 (1 US$ = Ksh 32.22 at the time of the survey) compared to Ksh 15085 to credit constrained farmers. Fifty seven percent of credit constrained farmers reported receiving a smaller loan than they requested while 37 percent of credit non-constrained farmers reported receiving smaller loans than they requested.

Relatively more borrowers irrespective of their credit constraint status used loans from formal institutions for purposes other than purchasing dairy cows. When all uses of loans are considered 38 percent of credit constrained farmers and 43 percent of credit non-constrained farmers reported that loans were used to purchase dairy cows.

3. Switching Regression Model of Impact of Credit on Milk Productivity

Many of the sites used in this study have a history of project interventions that promoted dairy development and credit activities. The selection criteria used in the study did not necessarily exclude farmers who were project beneficiaries. But one would expect that the most productive farmers were likely to be project beneficiaries who have had credit and improved inputs that enhance farm output.

A switching regression model is used to correct for possible sample selection bias which may arise from other interventions that provide multiple services to farmers in addition to credit (Lee, 1978; Madalla, 1983). Empirical application of this model to agriculture include studies by Pitt,1983; Feder et al.,1990; Goetz ,1992 ; Fuglie and Bosch, 1995. The two stage switching regression model applied in this study uses a probit model in the first stage to determine the relationship between farmers' credit constraint condition and a number of socio-economic and credit variables. In the second stage separate regression equations are used to model the production behavior of groups of farmers conditional on a specified criterion function.

The credit constraint condition of the i^{th} farmer is described by an unobservable excess demand function for credit, I^*, that is postulated to be a function of a vector of exogenous household socio-economic, herd characteristics, and credit variables.The relationship between excess demand for credit and the vector of explanatory variables is specified as:

$$I^* = \delta' Z_i + u_i \qquad (1)$$

where Z is vector of exogenous variables , δ is a vector of parameters and u_i is a random disturbance term that is distributed with zero mean and variance, σ^2.

The excess demand function for credit is not observed but responses from the survey is used to determine those households whose productive activities are constrained or not constrained by credit. Households are credit-constrained if the demand for credit exceeds the supply of credit, that is, $I^* > 0$. These responses are used to define a criterion function which is an observable dichotomous variable I:

$$\text{where} \quad I = 1 \quad \text{iff } I^* = \delta' Z_i + u_i \geq 0 \qquad (2)$$
$$I = 0 \quad \text{otherwise}$$

Probit maximum likelihood estimation is used to estimate the parameter δ in equation (2). It is assumed that var (u_i) = 1 since δ is estimable only up to a scale factor.

Following Feder et al. (1990) the production behavior of the two groups of farmers is modeled by reduced form equations specified by:

$$Y_{1i} = \beta_1' X_{1i} + u_{1i} \text{ iff } I = 1$$

and (3)

$$Y_{21} = \beta_2' X_{2i} + u_{2i} \text{ iff } I = 0$$

where X_{1i} and X_{2i} are vectors of exogenous variables, β_{1i} and β_{2i} are vectors of parameters, and u_{1i} and u_{2i} are random disturbance terms. Y_{1i} and Y_{2i} represent output supply functions for credit constrained and credit non-constrained farmers respectively.

Applying OLS to estimate the parameters β_1 and β_2 in equation (3) yields inconsistent estimates because the expected value of the error term conditional on the sample selection criterion is non-zero (Madalla, 1983). The random disturbance terms u_{1i}, u_{2i} and u_I are assumed to have a trivariate normal distribution with zero mean and a non- singular covariance matrix.

Maximizing the bivariate probit likelihood function for this model is feasible but time-consuming (Madalla, 1983). Therefore, following Lee (1978) a two-stage estimation method is used to estimate the system of equations in (2) and (3).

The conditional expected values of the error terms, u_{1i} and u_{2i} in equation (3) are:

$$E(u_{1i} | u_i \leq \delta' Z_i) = E(\sigma_{1u} u_i | u_i \leq \delta' Z_i)$$

$$= \sigma_{1u} \frac{\phi(\delta' Z_i)}{\Phi(\delta' Z_i)}$$

and

$$E(u_{2i} | u_i \geq \delta' Z_i) = E(\sigma_{2u} u_i | u_i \geq \delta' Z_i)$$

$$= \sigma_{2u} \frac{\phi(\delta' Z_i)}{1 - \Phi(\delta' Z_i)}$$

where ϕ and Φ are the probability density function and the cumulative distribution function of the standard normal distribution respectively. The ratio ϕ/Φ evaluated at $\delta' Z_i$ for each I is the inverse Mills ratio.

For convenience define:

$$\lambda_{1i} = \phi(\delta' Z_i)/\Phi(\delta' Z_i)$$

and (4)

$$\lambda_{2i} = \phi(\delta' Z_i)/[1 - \Phi(\delta' Z_i)]$$

These terms are included in the specification of equation (3) to yield:

$$y_{1i} = \beta_1' X_{1i} + \sigma_{1u} \lambda_{1i} + \_{1i} \qquad \text{if } I = 1$$

and (5)

$$y_{2i} = \beta_2' X_{2i} + \sigma_{2u} \lambda_{2i} + \_{2i} \qquad \text{if } I = 0$$

where ε_{1i} and ε_{2i}, the new residuals have zero conditional means. These residuals are, however, heteroscedastic. Therefore, estimating equation (5) by weighted least squares, WLS, rather than ordinary least squares, OLS, would give efficient parameter estimates.

Thus, the two stage estimation procedure that is used to estimate the model proceeds as follows. In the first stage probit maximum likelihood method is used to obtain estimates of δ from equation (2). By substituting the estimated values of δ for δ estimates are obtained for λ_{1i} and λ_{2i} from equation (4). In the second stage, equation (5) is estimated by WLS using the estimated values of λ_{1i} and λ_{2i} as instruments for λ_{1i} and λ_{2i} respectively.

4. Data

Cross-sectional surveys were conducted on a sample of smallholder dairy producers in Selale and Debre Libanos awrajas (administrative units similar to a district) in Ethiopia and Kiambu district in Kenya. These areas were identified as Livestock Production Zones (LPZ) with a history of smallholder dairying and credit activities. The sample comprised 74 households in Ethiopia and 94 households in Kenya. For the most part these farms were characterized as peri-urban dairy or mixed livestock farms (ILCA, 1995). Dairying is an integral component of these farms and household resource allocation and management decisions reflected the diversified nature of the production system. Data on household characteristics, resource endowments, milk production, milk disposal, input use, input cost, revenue, and credit transactions were collected by structured questionnaires between 1993 and 1994. Table 1 shows the description of the variables used in the analysis.

Descriptive statistics for relevant variables are shown in table 2. For the most part the same variables were used in the Ethiopia and Kenya model. However some of the variables used in one model could not be used in the other because the information was not available. For example information was not available on farm size in Ethiopia. Also farmers did not keep exotic cows in Ethiopia because they are prohibited to do so by law. To ensure that the statistical results were representative of the population from which the sample was drawn all continuous variables were weighted by total herd size.

The dependent variable in the first stage probit equation is farmers' credit constraint condition. This variable takes a value of 1 if a farmer is credit constrained and 0 otherwise. The explanatory variables comprised both continuous and binary variables. Household characteristics included the age, sex, educational status of the household head, the number of years the household head has spent in farming, participation of the household head in livestock training or seminars, and family size. The age and number of years spent in farming is used as proxy variables for experience in livestock farming. Attendance at livestock training and seminars is used as a proxy for improved management or animal husbandry practices because farmers receive training in various aspects of herd management, feeding and feed production strategies and disease control at these sessions.

Household resource endowment is measured by the size of the livestock herd in Tropical Livestock Units, TLU[2], and farm size. A site variable is included in the model to capture differences in production resources such as farm size and grazing land between the various locations in Ethiopia and Kenya. Economic variables are represented by total expenditure on variable inputs and a binary variable which measured whether farmers' gross revenue from farming was greater or less than the average gross revenue for the sample. Credit variables included whether a farmer had an outstanding loan during the survey period and their loan repayment record.

The dependent variable in the second stage regression is the log of total volume of milk output per farm in one year measured in liters. All other continuous explanatory variables were expressed in logs. Expressing the dependent and continuous explanatory variables in logs provides dimension less measures of the responsiveness of milk productivity to changes in input use. Since the coefficients of the regression equations are estimates of partial milk production elasticities the larger the coefficient the higher the response of milk productivity to marginal changes in input use. Negative coefficients indicate that milk productivity actually declines as the level of input increases.The explanatory variables representing household characteristics were, for the most part, identical to those in the first stage probit regression. Farmers' age and number of years spent in farming is used as proxy for farmers' experience. No a priori sign is expected on the experience variable because it is both possible that older farmers with more experience in dairying are more likely to recognize the gains from adoption of improved dairy technologies as well as being more conservative and less likely to adopt improved dairy technologies. Attendance at livestock training and seminars is hypothesized to be positively correlated with milk output per farm because farmers who had acquired specific livestock management training are expected to be better farm managers. Herd variables in the regression equations included the number of local, crossbred and exotic breed milking cows in the dairy herd. The number of crossbred and exotic milking cows are expected to be positively correlated with milk output per farm because these cows have genetically higher levels of milk production potential compared to local breed cows. The number of crossbred and exotic dairy cows are used as proxy for the impact of credit on smallholder dairy farms because most farmers used formal credit to purchase these cows (Freeman et al. 1998; Oluoch-Kosura and Ackello-Ogutu, 1998). Total expenditure on variable inputs is expected to have a positive influence on milk productivity. Surveys in Ethiopia and Kenya indicated that feed costs were the most important component of total variable cost (Freeman et al. 1998; Oluoch-Kosura and Ackello-Ogutu, 1998). It is hypothesized that farmers with relatively high expenditure on variable inputs are more likely to practice better nutrition management involving, among other things, use of purchased supplementary feeds. A binary variables indicating whether farmers' gross revenue were greater than, equal to, or less than the sample average is used as a proxy for farmers' liquidity position. The hypothesis here is that farmers with access to higher levels of liquidity have greater ability to purchase productive inputs that are likely to improve milk productivity. The

[2] A TLU is the standard unit by which livestock of different species are compared.

proxy variable measuring farmers' unobservable liquidity position is likely to cause endogeneity problems in the second stage estimation because current income was used to construct this variable. This problem is not considered to be serious in this case because of the lag between current income and milk production. Assuming that the disturbances are uncorrelated the proxy variable therefore is not likely to be contemporaneously correlated with the disturbance. One possibility for resolving the likely endogeneity problem is to discard the proxy for the unobservable liquidity regressor. But this also creates bias due to omitted variable problem. Following McCallum (1972) and Wickens (1972) the proxy variable for farmers' liquidity status is maintained in the regression equations on the grounds that the resulting asymptotic bias is less with using a poor proxy than omitting the unobservable regressor. [3]

The second stage WLS regression did not include the two credit variables representing whether a farmer had an outstanding loan and farmers' loan repayment record. The maintained hypothesis is that these variables are not likely to directly influence farm level milk output. Thus, the model is identified because there is at least one explanatory variable in the first stage probit regression that is not included in the second stage WLS regression (Maddala, 1983).

5. Empirical Results

Table 3 shows maximum likelihood estimates of the probit model for Ethiopia and Kenya. Marginal effects indicates the effect of one unit change in an exogenous variables on the probability that a farmer was credit constrained. These were estimated by $\phi(\delta Z)\underline{\wedge}$ calculated at the mean value of the regressors (Madalla, 1983). Marginal effects were estimated for continuous variables only because they may not be meaningful for binary variables (Greene, 1993).

Goodness-of-fit measures indicated that the estimated models fitted the data reasonably well. The choice of explanatory variables correctly predicted farmers' credit constraint condition for 86% of the observations in Ethiopia and 88% of the observations in Kenya. Likelihood ratio tests indicated that slope coefficients were significantly different from zero at 5% level of significance in both samples.

There was no relationship between farmers' borrowing status and their credit constraint condition in Ethiopia. However borrowing status was significantly related to farmers' credit constraint condition in Kenya. One explanation for the differential impact of borrowing as an important determinant of farmers' credit constraint condition in Ethiopia and Kenya is the differences in the effectiveness of institutional systems of credit delivery in the two countries. Even though both countries relied on co-operatives to deliver credit to smallholder farmers those in Kenya have had more success reaching smallholder farmers compared to Ethiopia. The total flow of institutional credit from various institutional credit sources to smallholder dairy producers in Ethiopia has been too small to make an impact on dairy production because credit policies and the credit delivery system discriminated against these producers

[3] The empirical results did not change significantly when separate regression were run with and without the proxy variable.

(Tilahun, 1994; Freeman et al, 1998). In contrast Kenya's dairy co-operatives were the most important source of credit for smallholder producers (Oluoch-Kosura and Ackello-Ogutu, 1998). These observations are consistent with our survey results which showed that 67% of borrowers in Kenya obtained loans from cooperatives while the corresponding proportion in Ethiopia was less than 30% (Freeman et al, 1998; Oluoch-Kosura and Ackello-Ogutu, 1998). The results therefore suggest that the functioning and effectiveness of credit delivery systems in different countries is perhaps one of the most important determinants of smallholder farmers' credit constraint condition because they largely determine their access to additional liquidity.

The differences in importance of borrowing status on farmers' credit constraint condition in the two countries also suggests that there is no unambiguous relationship between farmers' borrowing status and their credit constraint condition. This finding provides further support for the hypothesis that borrowers and non-borrowers are not homogenous with respect to their demand and supply of credit because it is possible to have both credit constrained and credit non-constrained farmers among borrowing and non-borrowing households.

Herd size was significantly related to farmers' credit constraint condition in Ethiopia and Kenya. The coefficient on herd size was negative in the Ethiopia equation but positive in the Kenya equation. Hence, credit constrained farmers were more likely to have smaller herd sizes in Ethiopia while credit non-constrained farmers were more likely to have smaller herd sizes in Kenya. Although credit non-constrained farmers tended to have smaller herds in Kenya, these comprise mainly exotic and crossbred cows with higher genetic potential for milk production compared to local breed cows. Total expenditure on variable inputs was not significantly related to farmers' credit constraint condition in both Ethiopia and Kenya. This finding is consistent with survey results where farmers reported using relatively small quantities of purchased variable inputs. Moreover, for those farmers who purchased variable inputs very few reported using credit for that purpose (Freeman et al., 1998; Oluoch-Kosura and Ackello-Ogutu 1998). Because the purchase of variable inputs was usually made from own resources and relatively small amounts of money were spent on those purchases compared to outlays for investments in dairy cows total expenditure on variable inputs was not relevant in determining the credit constraint condition of farmers. Site was significantly related to farmers' credit constraint condition in Ethiopia but not in Kenya. This variable probably captures most of the variation in grazing area. In Ethiopia sample farmers relied mostly on open access grazing therefore variation between sites was important. Areas with larger open access grazing area were more likely to have less liquidity constrained farmers because cash needs for purchased feed were relatively less. On the other hand in Kenya most farmers practiced stall feeding and hence had to rely on purchased feed. Under these circumstances variation in open access grazing was less likely to be an important determinant of farmers' liquidity constraint condition. Household characteristic variables such as age, sex, education and attendance of livestock training were significantly related to farmers' credit constraint condition in Kenya but not in Ethiopia. The importance of household specific characteristic in one location and not the other suggests that there is no unambiguous relationship between these characteristics and credit constraint condition. Therefore the relationship between these variables and farmers' credit constraint condition are specific to the location. To the extent that herd size and site were indicative of farmers' level of resource endowments these findings suggest that only the resource endowment structure was important in explaining the probability of their credit constraint condition in Ethiopia while both farmers' resource endowments structure and household characteristics were important determinant of credit constraint condition in Kenya.

The marginal effects, measured by marginal probabilities in Table 3, indicates that an additional unit of labor will have the largest impact on the probability of farmers' credit constraint condition in Ethiopia while an additional unit of livestock will have the largest impact on the probability of farmers' credit constraint condition in Kenya. The differences in marginal effects in the two locations suggests that while resource endowments might be important in determining the probability of farmers’ credit constraint condition there are likely to be wide variations in the importance of specific resources in different locations.

Reduced form WLS coefficient estimates of second stage switching regression models for milk output per farm are shown in tables 4 and 5. In Ethiopia the number of local and crossbred milking cows had positive coefficients and were significant in explaining variations in milk production on credit constrained farms while only crossbred milking farms were important determinants of milk output on credit non-constrained farms. However, an additional crossbred milking cow contributed about five times as much milk output per farm compared to an additional local breed milking cow on credit-constrained farms. Total expenditure on variable inputs was an important determinant of milk output on credit constrained farms but not on credit non-constrained farms. This suggests that for credit non-constrained farmers additional expenditure on variable inputs was not as much a constraint on milk production as additional investments in crossbred cows. Improved management through livestock training and seminars did not significantly influence milk output on credit constrained farms but it was important on credit non-constrained farms. This implies that efforts to increase milk output through improved management training might not be effective when farmers are constrained by credit. Improved livestock training therefore becomes more valuable under less constrained circumstances.

In Kenya the regression equations for credit-constrained farmers indicated that most of the variation in milk output per farm was explained by the number of local, crossbred and exotic milking cows. In contrast, only crossbred milking cows were important determinants of milk output on credit non-constrained farms. Similar to the Ethiopia result the number crossbred milking cows was the most important determinant of milk output compared to either local or exotic milking cows. An additional crossbred milking cow contributed about fives times as much to milk output per farm compared to an additional exotic milking cow on credit constrained farms while on credit non-constrained farms local and exotic cows were not even significant determinants of milk output. This finding suggests that despite the fact that the genetic potential for milk production is higher for exotic cows their on-farm performance can be substantially reduced. A likely explanation for the differences in on-farm performance of crossbred and exotic dairy cows is the greater susceptibility of exotic cows to environmental stress such as higher incidence of disease risk and relatively high managerial requirements. Total expenditure on variable inputs did not influence milk production on both credit constrained and credit non-constrained farms probably because relatively small amounts of purchased supplementary feed were used on these farms. Improved management skills through livestock training and seminars significantly influenced milk production on credit non-constrained farms although the negative coefficient on this variable was not intuitively appealing. Here it appears that knowledge of improved management skills does not translate into increases in farm level milk production. While this may be true it is also likely that this unexpected result is due to other confounding factors in the data set or the relatively small number of observations on farmers who had attended livestock training or seminars in Kenya. The coefficient for lambda was not significant in any of the regression equations. This suggests that the sample did no suffer from serious sample selection bias and that direct estimation of the model by OLS would have yielded unbiased estimates.

6. Conclusions and Implications

Smallholder dairy farmers in peri-urban areas of Ethiopia and Kenya are in an ideal position to satisfy growing urban demand for dairy products. To be able to do so these farmers must increase dairy productivity. This study provides additional evidence that credit from formal financial institutions enable smallholder producers to draw upon finances beyond their own resources and take advantage of productive opportunities. The results indicated that smallholder livestock producers in both Ethiopia and Kenya, particularly those who are constrained by liquidity, used credit from formal sources to invest in crossbred and exotic breeds of dairy cows with higher milk production potential. The marginal contribution of crossbred dairy cows was the most important determinant of milk productivity for all categories of farmers in both samples. Since formal credit facilitates investment in crossbred cows additional access to credit by smallholder livestock producers enhance farm level milk productivity which could be translated into substantial increases in aggregate domestic milk output in these countries.

The study shows that the marginal contribution of credit to milk productivity was different among credit constrained and non-constrained farmers. Using investment in crossbred dairy cows as a proxy for the use of credit the results imply that the marginal contribution of credit to milk productivity is relatively high on liquidity constrained farms compared to liquidity non-constrained farms. A 1 percent increase in credit used to purchase crossbred dairy cow leads to 0. 6 percent increase in milk productivity on credit constrained farms and 0.4 percent increase on credit non-constrained farms in Ethiopia. In Kenya a 1 percent increase in credit for investment in crossbred dairy cow leads to 1.6 percent increase in milk productivity on credit constrained farms and 0.9 percent increase on credit non-constrained farms. Similarly total expenditure on variable inputs significantly influenced milk production on credit constrained but not on credit non-constrained farms implying that the marginal productivity of working capital is different on these farms. These differences in the marginal contribution of credit to milk productivity among liquidity constrained and non-constrained farmers suggest that carefully targeted livestock credit schemes to those most in need are likely to have important equity and efficiency payoffs. Apart from contributing to milk productivity and income generation, keeping crossbred cows instead of the indigenous local breed cows allows farmers to hold smaller herds of more productive cows. The implication of this is that there would be less pressure on the resource base because stocking rates are likely to be reduced if farmers are encouraged to replace large herds of less productive local cows with smaller herds of more productive crossbred cows.

While investments in additional crossbred dairy cows has the greatest potential for smallholder milk production the full milk production potential from adoption of improved dairy technologies is not been realized. This is attributed, in part, to the fact that variable input use, as measured by expenditure on variable inputs and management practices, has not had much influence on milk production on smallholder dairy farms. This result is consistent with results from the survey in which few farmers reported using credit for the purchase of variable inputs such as feed (Freeman et al. 1998; Oluoch-Kosura and Ackello-Ogutu, 1998). In Ethiopia many farmers openly graze their herds and few use very small quantities of supplementary feed or health inputs. In Kenya where stall feeding is common, use of purchased inputs is still relatively low compared to optimal levels. In both cases use of purchased supplementary inputs at sub-optimal levels are likely to have significant effects on animal nutrition. Farmers consistently rated lack of liquidity higher than availability of input in explaining relatively low levels of utilization of purchased supplementary inputs. Reducing the liquidity constraint on use of supplementary inputs through making credit available for working capital can encourage higher levels of use and facilitate their optimum use. But the relative returns to investment in supplementary inputs have to be attractive for farmers to make the necessary investment given the alternative uses of scarce capital. Careful economic analysis is therefore necessary to assess the relative returns to farm level investments over a whole range of investments that farmers are likely to be making.

The results suggest that improved management skills through livestock training and seminars can positively influence milk productivity on credit non-constrained farms but not on credit constrained farms. Efforts to increase milk output through improved management skills might not be effective when farmers are constrained by credit. Thus dairy development programs with training components would only realize payoffs to their investments in training after the liquidity needs of farmers have been satisfied.

This study provides additional evidence on the importance of accurately assessing farmers' demand for credit. To do this policy makers and financial institutions need to go beyond whether farmers are borrowers or non-borrowers to take account of their resource endowments and household characteristics. An accurate assessment of farmers' credit constraint condition is important for credit policy because it provides useful insights into the circumstances under which credit is likely have the greatest impact. Returns to investments in credit programs would yield the greatest returns when there is differential targeting of credit by location. Additional credit can have the desired impact using existing institutional arrangements where there is a functioning credit delivery system which smallholder farmers have access to. On the other hand if credit delivery channels are not functioning or are not effective in reaching smallholder farmers substantial gains could be obtained from investments in credit delivery institutions which are accessible to farmers.

It is important to recognize that borrowers are not homogeneous in terms of their need for credit and that the marginal productivity of credit would be different even among different borrowers. Policy makers and financial institutions should carefully target those farmers most in need of additional capital in order to obtain the greatest impact from credit. There is also an additional need for understanding the use to which credit is being put. The full potential of credit on smallholder dairy production cannot be realized when credit is used only for investment capital. Credit for working capital, such as for the purchase of feed and veterinary services, are also important if smallholder farmers are to achieve the potential levels of milk production that is possible under their circumstances. Credit programs which incorporate farmer training are also likely to contribute the most to smallholder milk production because they benefit from the positive synergies between additional liquidity and the benefits from increased management training.

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Table 1: Description of Variables

Variable	Type	Description
AGE	Continuous	Age of household head in years
SEX	Binary	Sex of household head: 1 if household is male 0 otherwise
EXP	Continuous	Farmer's experience in livestock farming in years
FAMSIZE	Continuous	Family size
DEP	Continuous	The ratio of children to adults in the family
EDUC	Binary	1 if the farmer has formal education and 0 otherwise
LSTRG	Binary	Farmer's attendance at livestock training:1 if the farmer had attended and 0 otherwise
HSIZE	Continuous	Total herd size in TLU
MLBC	Continuous	Number of local breed milking cows
MCBC	Continuous	Number of cross-bred milking cows
MEXC	Continuous	Number of exotic breed milking cows
TOTMLK	Continuous	Total quantity of milk produced in survey period
FRMSZ	Continuous	Farm size in hectares
SITE	Binary	1 if the farmer is in Selale and 0 otherwise for Ethiopia; 1 if the farmer is in Githunguri and 0 otherwise for Kenya.
TOTVC	Continuous	Total expenditure on variable inputs
GRSRV1	Binary	1 if gross revenue is greater than or equal to average and 0 otherwise
GRSRV2	Binary	1 if gross revenue is less than average and 0 otherwise
LOAN	Binary	1 if the farmer is borrower and 0 otherwise
RPAY	Binary	Loan repayment: 1 if the farmer makes scheduled repayments and 0 otherwise
SEL	Binary	1 if the farmer is credit constrained and 0 otherwise

Table 2: Descriptive statistics for explanatory variables

Variable name	Ethiopia		Kenya	
	Mean	Standard deviation	Mean	Standard deviation
AGE	-	-	54.532	12.587
SEX	0.959	0.194	0.723	0.450
EXP	23.419	13.282	-	-
FAMSIZE	-	-	3.617	2.392
DEP	3.824	1.666	-	-
EDUC	0.662	0.426	0.851	0.358
LSTRG	0.284	0.454	0.330	0.473
HSIZE	35.051	14.524	6.273	3.693
MLBC	1.973	0.844	0.06	0.23
MCBC	1.838	1.007	2.192	1.050
MEXC	-	-	1.894	0.921
TOTMLK	2200	1255.7	3253.4	2709.5
FRMSZ	-	-	2.814	2.195
SITE	0.689	0.466	0.457	0.501
TOTVC	315.85	298.62	8245.7	8595.8
GRSRV1	0.432	0.499	0.117	0.323
LOAN	0.486	0.503	0.383	0.489
RPAY	0.216	0.414	0.309	0.464

Source: ILRI survey results

Table 3: Probit model for farmers' credit constraint condition

Variable name	Ethiopia		Kenya	
	Estimated coefficient	Marginal probability	Estimated coefficient	Marginal probability

AGE	-		-0.018025*	-0.0153
			(-3.1367)	
SEX	-0.39257		4.4456*	
	(-0.3765)		(2.8559)	
EXP	-0.00051	-0.0003	-	
	(-0.8391)			
FAMSIZE	-		0.046844	0.0266
			(1.6009)	
DEP	-0.21737	-0.173	-	
	(-0.6664)			
EDUC	-0.11159		-2.5310*	
	(-0.26503)		(-2.9959)	
LSTRG	0.57058		2.6230*	
	(1.0600)		(3.0552)	
HSIZE	-0.05254*	-0.051	0.76912*	0.7691
	(-1.9445)		(2.4913)	
FRMSZ	-		0.011175	0.0058
			(0.55986)	
SITE	-0.69025*		-0.52185	
	(-1.7895)		(-1.0513)	
TOTVC	-0.000009	-0.0000045	-0.000027	-0.000016
	(-0.4026)		(-0.85652)	
GRSRV1	-0.01647		-0.26320	
	(-0.0390)		(-0.26300)	
LOAN	-0.50879		5.2325*	
	(-0.8735)		(3.0786)	
RPAY	1.0441		-2.3136	
	(1.6442)		(-1.6893)	
CONSTANT	2.7447*		-4.1559*	
	(2.1472)		(-2.9832)	
Likelihood ratio test[a]	29.9060		67.1595	
Percentage of correct predictions	0.86486		0.88298	

Figures in parenthesis are asymptotic t-ratios * Significant at 0.1 level [a] Likelihood ratio tests were conducted with 11 d.f. for Ethiopia and with 12 d.f. for Kenya

Table 4: Reduced form WLS estimated coefficients of second stage switching regression model for milk output per farm: Ethiopia

Variable name	Estimated coefficient	
	Credit constrained	Credit non-constrained
SEX	-0.01220	-0.19135
	(-0.0225)	(-0.5035)
EXP	-0.14618	-0.23056
	(-0.7953)	(-1.322)
DEP	0.02224	-0.08710
	(0.1307)	(-0.6207)
EDUC	-0.34097	-0.37136*
	(-1.300)	(-2.167)
LSTRG	0.27591	0.40361*
	(0.9933)	(2.463)
MLBC	0.14536*	0.01594
	(2.279)	(0.2788)
MCBC	0.63260*	0.38519*
	(2.043)	(2.384)
SITE	-0.16004	-0.31455
	(-0.7852)	(-1.213)
TOTVC	0.18051*	0.00055
	(2.235)	(0.0073)
GRSRV1	0.33236	0.42436*
	(1.211)	(2.527)
LAMBDA	0.21403	0.63889
	(0.6100)	(1.721)
CONSTANT	7.1874*	11.644*
	(6.099)	(6.340)
ADJUSTED R^2	0.5707	0.5704

Figures in parenthesis are t-ratios

* Significant at 0.1 level

Table 5: Reduced form WLS estimated coefficients of second stage switching regression model for milk output per farm: Kenya

Variable name	Estimated coefficient	
	Credit constrained	Credit non-constrained
AGE	0.02967*	0.01647*
	(1.871)	(1.867)
SEX	0.05813	0.00751
	(0.0987)	(0.0335)
FAMSIZE	-0.55513*	-0.09445
	(-2.213)	(-0.7088)
EDUC	-0.86637	-0.18948
	(-1.378)	(-0.5949)
LSTRG	0.38647	-0.44151*
	(0.9896)	(-2.024)
MLBC	1.1447*	0.21100
	(2.948)	(0.7287)
MCBC	1.6145*	0.86926*
	(5.548)	(5.794)
MEXC	0.33441*	0.10054
	(2.497)	(1.266)
FRMSZ	-0.40681*	0.02530
	(-2.003)	(0.2204)
TOTVC	-0.007916	0.02094
	(-0.0581)	(0.3504)
GRSRV1	1.3096*	0.45487
	(2.431)	(1.665)
LAMBDA	0.17213	0.01889
	(0.5938)	(0.0504)
CONSTANT	6.2909*	6.7124*
	(4.241)	(8.460)
ADJUSTED R^2	0.7684	0.5311

Figures in parenthesis are t-ratios

* Significant at 0.1 level