Are Technology Adoption and Collective Action Important in Accessing Credit? Evidence from Milk Producers in Tanzania

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Abstract One of the targets of Sustainable Development Goal 2 is to double agricultural productivity and incomes of small-scale food producers through, among other things, improving access to financial services including credit. However, designing appropriate mechanisms for increasing access to credit by poor households remains a challenge, especially in Sub-Saharan Africa. This paper argues that technology adoption and collective action could provide pathways to enhancing access to credit. Evidence from milk-producing households in Tanzania suggests that group membership increases the probability of borrowing and the amount of funds borrowed by households, while adoption of artificial insemination increases the amount of funds borrowed. Two major conclusions are that public policy for increasing rural households' access to credit should promote collective action, and that the likely increase in amount of funds demanded by households due to technology adoption and collective action will require policy to address issues pertaining to credit rationing of rural households.

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Résumé L'un des Objectifs du Développement Durable, l'objectif 2, est de doubler la productivité agricole ainsi que les revenus des petits producteurs de denrées alimentaires, notamment en améliorant l'accès aux services financiers, y compris les crédits. Toutefois, la conception de mécanismes appropriés pour accroître l'accès au crédit par les ménages pauvres demeure un défi, en particulier en Afrique subsaharienne. Cet article fait valoir que l'adoption de technologies et l'action collective pourraient fournir des pistes pour améliorer l'accès au crédit. Les données issues des ménages producteurs de lait en Tanzanie suggèrent que l'adhésion au groupe augmente la probabilité d'emprunt ainsi que le montant des fonds empruntés par les ménages, tandis que l'adoption de l'insémination artificielle augmente le montant des fonds empruntés. Deux grandes conclusions sont que la politique publique visant à accroître l'accès des ménages ruraux aux crédits devrait favoriser l'action collective, et l'augmentation probable des fonds réclamés par les ménages en raison de l'adoption de technologies et de l'action collective exigera des politiques pour résoudre les problèmes liés au rationnement du crédit des ménages ruraux.

Keywords Technology adoption · Collective action · Credit access · Tanzania · Multinomial logit model · Binary logit model · Tobit model

Introduction

The second goal of the Sustainable Development Goals initiative of the United Nations is to end hunger and food insecurity, improve nutrition, and promote sustainable agriculture. One of the targets of this goal is to double agricultural productivity and incomes of small-scale food producers through, among other things, improving access to financial services including credit. Nobel Prize Laureate, Muhammad Yunus, has emphasised the centrality of credit to the welfare of poor households by suggesting that access to it should be considered a human right (Yunus 1987). Indeed, studies that have provided evidence of the importance of credit for rural households abound (see, e.g., Freeman et al. 1998; Abdulai and Huffman 2005; Swaminathan et al. 2010; Fischer and Qaim 2012; Shoji et al. 2012; Ali and Deininger 2012; Jia et al. 2013). However, accessing credit remains a big challenge for poor households in developing countries.

Mogues et al. (2015) observed that rural credit markets in developing countries are characterised by information asymmetries, yet government subsidies for rural credit provision have not necessarily addressed this challenge. In fact information asymmetries have been found to curtail the ability of microfinance institutions to achieve their poverty reduction objectives (Annim 2012). It is possible that agricultural subsidy programs for credit-constrained farmers end up as sources of household income for investing in areas such as children's education—as has been the case in parts of Europe (Berlinschi et al. 2014)—rather than improving access to credit. Therefore in order to determine areas in which public investments can be made to sustainably increase access to credit by poor households, it is imperative to understand the factors that influence their access to it.

This paper attempts to estimate the determinants of access to credit by rural households. It particularly focuses on the role of agricultural technology adoption and collective action as potentially important technological and institutional pathways through which public funds can be invested to help increase access to credit, but for which there has not been consensus in the theoretical and empirical literature. For instance, Bell (1988) observed that the influence of technology adoption on access to credit is ambiguous. On the one hand, the adoption of new technology could lead to the need for new inputs and practices that require extra working capital. This could in turn motivate adopters to either actively seek for credit or implement production and management decisions such as record keeping that make them attractive to lenders. This view is consistent with Swain's (2007) observation that access to credit partly depends on factors that influence the lender's perception of the credit worthiness of potential borrowers. In addition, to the extent that new technology increases productivity and hence expected returns, it might, at a given rate of interest, permit hitherto non-borrowers to borrow. However, on the other hand, if borrowers and lenders associate technology adoption with greater risk, it could suppress loan demand and/or lead to usurious lending, thereby constraining access to credit, especially in the absence of insurance. This means that, in the presence of technology risk, prudent policies for rural finance ought to provide for access to insurance in promoting access to credit.

Collective action, defined here as the voluntary action by a group of people to pursue a common interest (Markelova and Mwangi 2010), is one of the elements that have underpinned the formation of some credit schemes such as the savings and credit cooperative societies (SACCOS) being implemented in various parts of Africa. In Tanzania, the Cooperatives Act of 1991 allowed for the establishment of SACCOS, and the Cooperative Development Policy of 2002 supports SACCOS as an important channel through which financial services are to be provided to rural households. However, market liberalization in Tanzania, which saw a huge reduction in public investment in agricultural service provision, caused a significant decline in credit supply by cooperatives (Ponte 2001). Moreover, membership of cooperatives by some sections of rural producers remains low. Therefore, the effectiveness of collective action in increasing access to credit remains an empirical question.

Given the paucity of studies that have analysed the effect of technology adoption and collective action on access to credit and the lack of consensus among the few that have attempted to do so, this study draws upon existing conceptual notions to pursue the subject further for the case of milk producers in Tanzania. The type of dairy cattle technology considered in this study is the use of artificial insemination (AI) in herd breeding and expansion, while the form of collective action analysed is a household's membership in a self-help producer group. Both AI and membership in producer groups have been identified in the country's livestock modernisation initiative as being crucial for herd improvement and growth of the dairy industry (Ministry of Livestock and Fisheries Development 2015). A recent study has established that AI has the potential to facilitate households in Tanzania to transition from extensive non-commercial milk production to intensive commercial production (Dizyee et al. 2017).

The remainder of the paper is organised as follows: the next section reviews previous research on the subject, followed by a conceptual framework in section three. We then present the empirical methods used in the analysis in section four. Data and descriptive statistics are discussed in section five. Estimation issues arising from the empirical approach and the results obtained are presented and discussed in section six. The last section summarises and concludes the study.

Related Research

A survey of some of the earlier theoretical and empirical literature on access to credit is provided by David and Meyer (1979). They noted that single-equation models of borrowing applied to cross-sectional data had typically been used to estimate credit access relationships in low-income countries. This appears to have remained the case in more recent literature, and the explanatory variables used in most empirical studies have generally been consistent with those described by the authors. These variables have included interest rates, farm production characteristics, investment opportunities such as factor endowments, technological change and higher farm prices, institutional arrangements such as collective action, and household demographic and socioeconomic factors.

Generally, there are two common strands of literature on access to credit: one strand has dealt with a household's probability of participating in the credit market, while the other has dealt with the outcome of that participation in the form of loan amounts borrowed. The probability of participating in the credit market can be analysed with probability models of the binary response type. Guirking (2008) investigated the probability of households in Peru accessing an informal loan, and found that households that are credit-rationed with respect to the desired amount of funds, transaction costs, and the risk implied by available formal loan contracts were significantly more likely to borrow from the informal credit market. In rural China, the probability to obtain informal credit is positively correlated with the size of a household's social network and its wealth endowment, among other things (Yuan and Xu 2015). Fatima (2009) found that the chances of rural women in Pakistan obtaining credit increase with age, marriage and employment. In rural India, the probability of borrowing increases with agricultural land holding and the presence of irrigation on farmland (Pal and Laha 2015), the latter of which could be construed as a measure of technology adoption. In a field experimental study of farmers in Malawi, Giné and Yang (2009) found that bundling insurance (against production risk) with production credit significantly reduced the probability of borrowing since the mandatory insurance premium increases the overall interest rate on the loan. They also found that borrowers' education, income and wealth were strong predictors of the probability to obtain credit insured against production risk.

The strand of literature dealing with loan amounts borrowed includes studies such as Iqbal (1983) for rural India, De Jesus and Cuevas (1988) and Briones (2009) for rural Philippines, and Atieno (1997) for Kenya. Iqbal (1983) used total land owned by a household as a proxy for initial endowment and found that it negatively influenced the amount of funds borrowed. However, in Kenya, Atieno (1997) found that

this variable increased the funds borrowed. In addition, Iqbal (1983) used village development unit shares of research expenditure and proportion of area planted with high-yielding varieties as proxies for technical change and found that both variables positively influenced the amounts borrowed. De Jesus and Cuevas (1988) found that the proportion of irrigated land increased the level of borrowing but the effect of membership of a household in a farmer organisation was negative, contrary to their *a priori* expectation. The authors suspected that membership of farmer organizations likely enabled households to internally finance their production activities. Controlling for the endogeneity of the type of loan, Briones (2009) found that the value of farm equipment (a proxy measure for access to or adoption of technology) significantly increased the loan amounts borrowed.

Some studies have analysed both the probability of borrowing and amounts borrowed. Swain (2007) applied type 3 tobit and double hurdle models to Indian data and found that net wealth, size of land owned and education, among other variables, positively influenced households' access to credit. Khoi et al. (2013) applied the conditional recursive mixed process—a combination of tobit, probit and Heckman two-step models—to households in the Mekong River Delta in Vietnam. They found that land ownership was one of the factors that increased access to informal credit, while education and membership in a credit group were some of the factors that increased access to formal credit. Close to Tanzania, Mpuga's (2010) study applied probit and tobit models to Ugandan households. Consistent with most studies reviewed here, education was found to significantly increase access to credit.

A study that is somewhat similar in spirit to this study was that by Jabbar et al. (2002). The study analysed access to credit among smallholder dairy producers in Ethiopia, Uganda and Kenya. All farmers surveyed in the three countries were found to use one or more improved dairy cattle technologies, including crossbred or purebred exotic animals, AI, veterinary drugs and services, improved fodder and concentrate feeds, and improved husbandry practices such as barn construction. The incidence of borrowing was found to be 49% in Ethiopia, 79% in Uganda and 40% in Kenya. The effect of the adoption of one technology—improved dairy breeds (captured as the number of crossbred cow equivalents)—on the decision to borrow was estimated using a logistic regression model, and mixed results were obtained; the effect was negative in Ethiopia and Kenya, but positive in Uganda. Ethiopia and Kenya had relatively high average crossbred cow equivalents, yet the loans were provided for acquisition of dairy breeds. As such, dairy farmers with high proportions of improved dairy breeds would not qualify for the loans. The study did not consider the level of borrowing and also did not examine the role of collective action in accessing credit. This is the gap we seek to fill, in addition to accounting for the influence of a technology that would in essence produce crossbred dairy cattle.

Conceptual Framework

Access to credit by rural households has been observed to be influenced by factors on the supply-side such as credit rationing by lenders, and on the demand-side such as profitability of borrowers' enterprises (Swain 2007; Simonette et al. 2007). Even

more ambiguous is that the influence of the two covariates of interest in this study—technology adoption and collective action—can be conceptualised from either side. Besides information asymmetries, there are three important contextual issues regarding rural credit that could have a bearing on modelling its accessibility. First is that, in low-income countries such as Tanzania, the subsistence nature of production means that production and consumption decisions are necessarily intertwined, implying that disregarding the fungible nature of credit (Hussain and Thapa 2016), a production loan may well be regarded as a consumption loan and vice versa. In other words, there is no clear distinction between production and consumption credit (Lipton 1976). As such, a household's ability to access credit cannot be associated solely with either its utility or profit-maximising behaviour.

Second is the interlocked nature of credit transactions (Crow and Murshid 1992). When credit is linked to output (the so-called commodity-credit market interlinkage), the lender, who may also be a trader, provides the farmer with a loan, either in cash or kind, on condition that the farmer sells all or part of his produce to them. Loan repayment is then deducted from (checked off) payment for the produce. The trader-cum-lender usually lives in the same village as the farmer and possesses considerable information about the farmer's ability to repay the loan. Such credit transactions are characterised by personal and social relationships. As such, interest rates tend not to be entirely exogenously determined. They could be zero, or less than or greater than market rates, depending on the price the lender pays for the commodity. This study was conducted in an area where research for a development project led by the International Livestock Research Institute was facilitating the strengthening of interlinked credit arrangements. The arrangements interlock input and output transactions where milk producers access the desired inputs and services on credit with their milk delivery as collateral.

Third is the issue of physical collateral that is often not appropriate enough to either deter loan default or dispose of in the event of default. The former is usually due to the joint ownership by extended families of physical assets such as land and livestock that could be used as collateral, while the latter is due to the same, as well as social relationships and cultural values that make it hard for a community member to acquire assets of a neighbour who is experiencing financial difficulties. This has resulted in low levels of collateral-based lending, yet the levels of cash flow-based lending also remain low because potential borrowers' cash flows are largely unobservable to the lender. Consequently, some formal lenders in Tanzania, such as the Covenant Bank for Women (Tanzania) Ltd., finance acquisition of dairy cattle by smallholders and large-scale farmers without requiring physical collateral. Instead, the Bank requires a potential borrower to be a member of a group of dairy farmers operating a joint account with the Bank, and it is the deposits on the account that serve as collateral. Borrowers also maintain individual accounts with the Bank. The Bank directly pays the cattle supplier and links each farmer group to a milk collector (trader) whom it financially facilitates and whom holds an account with the Bank. Payments for milk are deposited in the groups' account and are then distributed to members by the Bank through individual accounts.

Given the above considerations, neither the widow's cruse theory of credit supply advanced by Bottomley and Nudds (1969) nor the utility maximisation framework

described by David and Meyer (1979) can be used to precisely account for the role of technology adoption and collective action in rural households' access to credit. A suitable conceptual framework can be derived from the highly interdisciplinary human development theory advanced by Nobel Laureate Amartya Sen. Sen (1999) argued that economic development is a process that involves expanding five inter-related freedoms that are instrumental to advancing the capabilities of people. The freedoms include political freedom, economic facilities, social opportunities, transparency guarantees, and protective security. Sen (2003) defined capability as what a person manages to do or to be, and it reflects their freedoms. The theory has thus yielded the capability approach to evaluating individual and social welfare.

Economic facilities are defined as opportunities to utilise economic resources for production, consumption or exchange, and one such facility is finance (Sen 1999). Sen emphasises the interrelationships among the different freedoms, and it is from those interrelationships that we are able to conceptualise the effect of technology adoption and collective action on access to credit. For instance, he observes that social opportunities, which are defined as "arrangements that society makes for education, healthcare and so on... are important for... more effective participation in economic activities..." (Sen 1999, p. 39). Social opportunities include social capital (social values, norms and networks), and the collective action it supports in rural areas. Therefore, it is reasonable to expect rural households to engage in collective action in order to access credit and, consequently, achieve greater participation in economic activities. In this study, membership of a self-help group is used as a proxy for collective action. Group membership may improve a household's perception of their credit worthiness and hence encourage them to borrow. It could also lead to greater access to information about the available sources of loans and their terms and conditions, and could encourage group members to seek credit from formal credit institutions which rely on peer monitoring to ensure loan repayment. In essence, group membership serves to reduce information asymmetries for both borrower and lender. Also, we hypothesise that group membership as a mechanism for farmer capacity building and access to business development services increases the desire for greater commercialisation of milk enterprises and hence the level of borrowing.

Technology affects production possibilities, which would in turn affect the range of economic opportunities including access to credit that a household can exploit. More specifically, the use of AI might improve the productivity of a household's herd and returns from it and hence improve the ability of the household to borrow funds. Also, AI could lead to the demand for different and more expensive types of inputs—hence an increase in the probability and level of borrowing—as the proportion of crossbred cattle in the household's herd increases. And in the matter of information asymmetries, AI is a technology that reduces production risk and leads to better and more observable cash flows. This is likely to improve lenders' perception of the credit worthiness of AI adopters.

Other potential determinants of access to credit include interest rates, the household's permanent income, land ownership, education of household heads, age of household heads, sex of household heads, distance of the household from the nearest trading centre, and type of cattle feeding system. Permanent income is a function

of current and past income (Iqbal 1983). In this study, current household revenues from various sources are used as proxies for permanent income, which indicates the loan repayment capacity of a household, notwithstanding collateral pledged. Generally, an increase in income would increase the likelihood and level of borrowing, but the study is also interested in determining the specific source(s) of income that would increase borrowing. Total land owned by a household may be considered as a measure of the household's initial resource endowment and repayment capacity, especially when collateral is a prerequisite for acquiring a loan. Education of the household head is an indicator of the household's capacity to negotiate for and manage a loan. Age of the household head captures experience in seeking for and managing credit. Sex of the household head influences borrowing insofar as it determines access and ownership of productive assets and decision making. Because of the patriarchal nature of communities in the study areas, male-headed households are likely to have greater access to credit than female-headed households. A household's distance from the nearest trading centre determines accessibility to information, business services (including financial services) and infrastructure.

Our sample is obtained from areas characterised by two types of cattle feeding systems: intensive feeding system in Lushoto district and extensive feeding system in Handeni, Mvomero and Kilosa districts. Households in the intensive feeding system stall-feed their animals, while those in the extensive feeding system are mostly pastoral in nature. The intensive feeding system has had a longer history of—and hence benefited more from—dairy sector interventions than the extensive feeding system. This is partly because pastoral cattle keepers in the extensive system have in the past been highly transhumant. Therefore, cattle keepers in intensive cattle feeding systems are likely to have greater access to credit than their counterparts in extensive systems.

Empirical Approach

Our empirical approach to examining access to credit consists of two steps: examining the decision to borrow, and then the amount of funds borrowed. According to Sen's capability approach, "capability reflects a person's freedom to choose between different ways of living" (Sen 2003, p. 5). This means that a household's decision to borrow can be empirically modelled as a choice, given the household's social, economic and environmental circumstances. We apply the random utility framework for choice modelling to this end. This study deviates from previous studies that have treated access to credit by rural households as a case of only two discrete categories: borrowers and non-borrowers. Borrowers are households or individuals whose access to credit is observable, while non-borrowers have comprised only those households or individuals who have sought for credit but have been unable to acquire it. However, in investigating the decision to borrow, it would be instructive to consider the possibility that some non-borrowing households that have not sought for credit are not necessarily without a credit constraint but rather are potential borrowers who have excluded themselves from borrowing because of high credit

application costs (Kon and Storey 2003) or they were previously credit-rationed (Simtowe et al. 2008).

Stiglitz and Weiss (1981) define credit rationing as a situation in which either some loan applicants who are indistinguishable from others are denied loans even if they are willing to pay a higher interest rate, or some distinct groups of individuals are unable to acquire credit at any interest rate, but could do so at a higher level of credit supply. Credit rationing has been observed in Tanzania (Bigsten and Danielson 2001; Weber and Musshoff 2012) and certainly credit application is not costless for remote rural households. The methodological implication of omitting from the analysis households that did not seek for credit is that it could lead to biased results. In fact in their analysis of credit access, Jabbar et al. (2002) find that not all borrowers had a credit constraint and that some non-borrowers actually had a credit constraint. Therefore in this study, we further categorize non-borrowers into two groups: those that did not seek for credit, and those that sought for credit but were unable to acquire it. We test the null hypothesis that the two groups of non-borrowers are statistically different. Failure to reject this hypothesis would imply that non-borrowers who did not seek for credit probably excluded themselves from borrowing or are not credit-constrained.

We consider three categories of households; category 1 households chose not to seek for credit, category 2 households chose to seek for but did not acquire credit, and category 3 households chose to seek for and acquired credit. We use a multinomial logit model to predict the probabilities of a household falling into the different categories given a set of explanatory variables, and to determine whether or not the different categories are statistically independent. We apply the model to our data with a dependent variable denoted *CATEGORY* and coded 1, 2 and 3, where category 1 is the reference category. Our strategy is that if, from the multinomial logit model, we find the three categories of households to be independent, category 1 can be disregarded and the probability of borrowing can then be examined using a binary logit model.

The second step of our empirical approach involves estimating the determinants of the amount of funds borrowed. Owing to the censored nature of our sample data, we follow Iqbal (1983), De Jesus and Cuevas (1988), Duong and Izumida (2002) and Swain (2007) and employ the tobit (censored regression) model. It is an extension of the probit model, and its log-likelihood is the sum of two parts; one part corresponds to the probability of borrowing by households that did not borrow, and the other part is the classical regression for households that borrowed.

Data and Descriptive Statistics

The study is based on a June–September 2014 survey of 461 households that were randomly selected from lists of milk-producing households in four districts of Tanzania: Lushoto and Handeni in Tanga region, and Kilosa and Mvomero in Morogoro region. Milk producers in Lushoto practice intensive (stall) feeding of animals because of limited land and the district's hilly topography, while those in the other three districts are mostly extensive cattle feeders. Data were collected

using a structured questionnaire (available from the authors) administered through face-to-face interviews. Variables on which data were collected include, among others, household demographic and socioeconomic characteristics, access to credit in the 6 months prior to the survey, amount of funds borrowed, interest rates charged, ownership of productive assets such as land and livestock, dairy technologies used, revenues from various sources, and distance between a household and the nearest trading centre. Summary statistics of selected variables for all categories, categories 1 alone, and categories 2 and 3 combined are presented in Tables 1, 2 and 3, respectively.

The statistics reveal that, overall, 31% of all households use AI either alone or in combination with the use of their own bulls or other farmers' bulls to breed their cows. The average cost of a single AI service in all districts was found to be 14,615 Tanzanian Shillings (\$8.12 USD), and the majority of farmers in the extensive feeding system found it to be expensive relative to other breeding methods. Membership of one or more groups was obtained by type of group. Almost half of the surveyed households have at least one member participating in a group, and livestock groups have the largest number of households across the four districts; more than three-quarters of households holding group membership belong to a livestock producer group.

Results

Incidence of Credit

Only 31 households sought for and acquired credit in the 6 months prior to the survey. Therefore, the incidence of credit is 7%, which is lower than that obtained by Jabbar et al. (2002) for Ethiopia, Uganda and Kenya. Twenty-six percent of the households (122) sought credit but did not acquire it, while 67% (308) did not seek credit. As earlier mentioned, we suspect some of the latter to have excluded themselves from borrowing. Mohamed (2003) and Salami et al. (2010) have observed that there has been low access to credit in rural Tanzania, especially after the collapse of most cooperative unions following the liberalisation of the country's financial sector in the 1990s (Rweyemamu et al. 2003). For instance, in spite of more than a decade of government support through the Cooperative Development Policy of 2002 for rural savings and credit cooperative societies (SACCOS), Covarrubias et al. (2012) found that only 6% of livestock-keeping households had membership of these cooperatives, and, consistent with the current study's finding, only the same proportion held credit. Moreover, participation in informal savings and credit schemes such as the rotating savings and credit associations was found to be as low as 4.3% in the Kilimanjaro region (Kimuyu 1999). The government of Tanzania recognises that lack of adequate credit for agricultural production and marketing is an obstacle to increasing the competitiveness of the agricultural sector and therefore supports the development of sustainable rural financial services as part of its rural development strategy (United Republic of Tanzania 2001).

Table 1 Summary statistics of selected variables for entire sample; $n = 461$

Label	Description	Mean	SD	Min	Max
CREDIT	Household acquired credit in last 6 months (1 = Yes; 0 = No)	0.07	0.25	0	1
LOAN	Total amount of money borrowed in last 6 months (TZS)	538,387	1,426,562	15,000	8,000,000
INTEREST	Monthly interest rate on loans (%)	2.76	2.66	0	10
HHSIZE	Number of people in a household	6.07	2.36	1	19
DISTANCE	Distance of household from nearest trading center (km)	7.74	9.20	0.001	54
EDUCATION	Number of years of schooling of household head	4.71	3.61	0	16
AGE	Age of household head (years)	46.83	13.62	18	85
LAND	Size of land owned by household (acres)	17.35	49.36	0.25	675
HERDSIZE	Number of cattle owned by household	47.83	142.01	1	2280
GROUP	Household has member in a group (1 = Yes; 0 = No)	0.47	0.50	0	1
AI	Household uses artificial insemination (1 = Yes; 0 = No)	0.31	0.46	0	1
FEEDSYS	Type of cattle feeding system (1 = Intensive; 0 = Extensive)	0.33	0.47	0	1
REVCAT	Household revenue from cattle sales last 6 months (TZS)	503,562	1,453,470	0	2.05E+07
REVOTHERCAT	Household revenue from cattle products other than milk (TZS)	24	269	0	5000
REVCATSERV	Household revenue from cattle services such as draught power (TZS)	6356	60,001	0	1,000,000
REVCROP	Household revenue from crop sales in last 6 months (TZS)	110,723	956,135	0	2.0E+07
REVOTHER	Household revenue from other sources (TZS)	349,184	1,235,116	0	1.0E+07

44 households (9.54%) were female-headed
TZS Tanzania Shillings

Table 2 Summary statistics of selected variables for category 1; $n = 308$

Label	Description	Mean	SD	Min	Max
HHSIZE	Number of people in a household	5.71	2.07	1	14
DISTANCE	Distance of household from nearest trading center (km)	9.26	12.53	0.25	54
EDUCATION	Number of years of schooling of household head	4.33	3.56	0	14
AGE	Age of household head (years)	45.69	14.24	18	85
LAND	Size of land owned by household (acres)	11.91	21.42	0.25	209
HERDSIZE	Number of cattle owned by household	53.53	167.18	1	2280
GROUP	Household has member in a group (1 = Yes; 0 = No)	0.41	0.49	0	1
AI	Household uses artificial insemination (1 = Yes; 0 = No)	0.26	0.44	0	1
FEEDSYS	Type of cattle feeding system (1 = Intensive; 0 = Extensive)	0.32	0.47	0	1
REVCAT	Household revenue from cattle sales last 6 months (TZS)	482,020	1,550,727	0	2.05E+07
REVOTHERCAT	Household revenue from cattle products other than milk (TZS)	29.55	318.70	0	5000
REVCATSERV	Household revenue from cattle services such as draught power (TZS)	389.61	6,837.64	0	120,000
REVCROP	Household revenue from crop sales in last 6 months (TZS)	63,404.68	234,767.50	0	2,320,000
REVOTHER	Household revenue from other sources (TZS)	300,071.40	1,189,249	0	1.00E+07

30 households (9.74%) were female-headed

TZS Tanzania Shillings

Table 3 Summary statistics of selected variables for categories 2 and 3; $n = 153$

Label	Description	Mean	SD	Min	Max
LOAN	Total amount of money borrowed in last 6 months (TZS)	109,085	669,924.50	0	8,000,000
INTEREST	Monthly interest rate on loans (%)	2.40	6.38	0	30
HHSIZE	Number of people in a household	6.79	2.72	2	19
DISTANCE	Distance of household from nearest trading center (km)	7.64	14.35	0.001	37
EDUCATION	Number of years of schooling of household head	5.48	3.59	0	16
AGE	Age of household head (years)	49.20	13.02	22	85
LAND	Size of land owned by household (acres)	28.31	79.16	0.25	675
HERDSIZE	Number of cattle owned by household	36.37	66.23	1	499
GROUP	Household has member in a group (1 = Yes; 0 = No)	0.61	0.49	0	1
AI	Household uses artificial insemination (1 = Yes; 0 = No)	0.42	0.49	0	1
FEEDSYS	Type of cattle feeding system (1 = Intensive; 0 = Extensive)	0.36	0.48	0	1
REVCAT	Household revenue from cattle sales last 6 months (TZS)	546,928	1,238,352	0	9,500,000
REVOTHERCAT	Household revenue from cattle products other than milk (TZS)	13.73	119.65	0	1050
REVCATSERV	Household revenue from cattle services such as draught power (TZS)	18,366	102,876	0	1,000,000
REVCROP	Household revenue from crop sales in last 6 months (TZS)	205,978.40	1,625,316	0	2.00E+07
REVOTHER	Household revenue from other sources (TZS)	448,051.60	1,321,141	0	1.00E+07

14 Households (9.15%) were female-headed
TZS Tanzania Shillings

Table 4 Transformation of continuous variables

Variable	Binary form
DISTANCE	> 5 km = 1; 0 otherwise
EDUCATION	> 0 = 1; 0 otherwise
HHSIZE	> 5 members = 1; 0 otherwise
AGE	> 24 years = 1; 0 otherwise
LAND	> 1 acre = 1; 0 otherwise
HERDSIZE	> 5 animals = 1; 0 otherwise
REVCAT	> 0 TZS = 1; 0 otherwise
REVOTHERCAT	> 0 TZS = 1; 0 otherwise
REVCATSERV	> 0 TZS = 1; 0 otherwise
REVCROP	> 0 TZS = 1; 0 otherwise
REVOTHER	> 0 TZS = 1; 0 otherwise

Estimation Issues and Regression Results

Summary statistics of continuous variables show that most of them range from small to excessively high numbers. This is likely to be a problem in logistic regressions. Indeed, preliminary regressions with these variables in their continuous form produced parameter estimates that were very close to zero and hence potentially misleading. And although there were some outliers in the data, we did not have a strong theoretical justification for excluding them from the analysis. A logarithmic transformation could be used to deal with outliers but it does not guarantee that very extreme outliers will not affect model parameters. To circumvent this problem, the variables were carefully operationalised, as shown in Table 4. Although this might reduce the information contained in the dataset, it provided more meaningful results for this study.

Operationalisation of the variables was based on our knowledge of the study sites and Tanzania's socioeconomic and demographic context. With respect to distance of a household from the nearest trading centre, we regard a distance greater than 5 km to be reasonably long given the poor roads, poor road network and limited means of transport that are characteristic of most villages in the study sites. Household heads that had attended school were considered to have acquired basic literacy skills unlike those that did not. Binning of household size was based on the national average of 4.8 (United Republic of Tanzania 2013), while binning of age of household head was based on the United Nation's upper limit of 24 years in its definition of youth (United Nations Development Programme 2014). Households that own one to five animals are considered to be smallholder cattle keepers (Njombe et al. 2012). Regarding the influence of income, it would suffice to consider whether or not a household derives income from a given source as opposed to how much income it acquires from that source.

We present regression results of the three models that fitted the data best and, as such, the sets of explanatory variables necessarily differ. Table 5 summarises results of the multinomial logit model with category 1 (households that did not

Table 5 Regression results from the multinomial logit model

Variable	Category 2		Category 3	
	Coefficient	RRR	Coefficient	RRR
EDUCATION	0.53* (0.28)	1.705	1.09**	2.982
AGE	0.79 (0.80)	2.202	12.25***	209,196.20
SEX	-0.07 (0.41)	0.935	0.65	1.922
LAND	0.74 (0.46)	2.106	-0.52	0.594
GROUP	0.44** (0.23)	1.559	2.19***	8.936
AI	0.43* (0.25)	1.533	0.60	1.820
REVCATSERV	3.21*** (1.00)	24.822	2.26	9.620
CONSTANT	-3.18*** (0.89)	0.041	-16.68***	5.68E-08
<i>n</i> = 461				
LR χ^2 (30) = 87.92				
Prob > χ^2 = 0.000				
Pseudo- R^2 = 0.098				
Log pseudolikelihood = -333.984				

Dependent variable is Category, coded 1 = household chose not to seek for credit, 2 = household chose to seek for credit but did not get it, and 3 = household chose to seek for credit and got it. Base category is category 1

Figures in parentheses are standard errors

RRR relative risk ratio

***, ** and *denote significance at 1, 5 and 10%, respectively

seek for credit) as the base category. As defined earlier, category 2 includes households that sought for but did not acquire credit, while category 3 is for households that sought for and acquired credit. The likelihood ratio test of the null hypothesis that all regression coefficients across all equations are simultaneously equal to zero yields a Chi-squared (χ^2) statistic of 87.92 with a p value $\equiv P[\chi^2(30) > 87.92] = 0.000$. Since $0.000 < 0.01$, we reject the null hypothesis at the 1 % level of significance. Therefore the data suggest that at least one of the regression coefficients is not equal to zero. The pseudo (McFadden)- R^2 gives a measure of goodness of fit, whereby the higher the value, the better. But it is not qualitatively similar to the R^2 in ordinary least squares regression models. Gujarati (2003) cautions that goodness of fit is not a particularly meaningful concept in qualitative response models, and that what is important is the signs and statistical significance of the regression coefficients.

We also used the likelihood ratio test to compare the three categories. This test essentially compares two statistical models, with one nested in the other. Using the maximum likelihood method, we fit both the unrestricted and restricted models, where the latter is nested in the former. For instance, in comparing categories 1 and 2, the unrestricted model is the full model with category 1 as the base category, while the restricted model has category 1 as the base category but all coefficients (except the constant) of category 2 are set to zero. In comparing categories 2 and 3, we set category 2 as the base category for both unrestricted and restricted models, and in the latter, all coefficients (except the constant) of category 3 are set to zero. Note that in a multinomial logit model, all coefficients of the base category are automatically constrained to zero.

Likelihood ratio tests of the null hypotheses that there is no difference between the different categories produced the following χ^2 values: 51.82 for category 1 versus category 2 with a p value $\equiv P[\chi^2(15) > 51.82] = 0.000$, 43.85 for category 1 versus category 3 with a p value $\equiv P[\chi^2(15) > 43.85] = 0.000$, and 24.11 for category 2 versus category 3 with a p value $\equiv P[\chi^2(15) > 24.11] = 0.063$. Therefore for category 1 versus category 2, and category 1 versus category 3, we reject the null hypotheses at the 1% level of significance, whereas for category 2 versus category 3, we reject the null hypothesis at the 10% level of significance. We conclude that households that did not seek for credit are different from those that sought for credit but did not get it. The former probably comprise those that genuinely did not need credit and those that exercised self-exclusion from the credit market. Disaggregated empirical analysis of those that did not need credit and those that exercised self-exclusion is, however, beyond the scope of this study.

Testing the above hypotheses was the main purpose of the multinomial logit model, and the results of the tests have justified the need for us to proceed with a logit model. However, the multinomial logit model results also provide initial insights into the likely influence of AI and group membership as well as clues as to other variables that could be important covariates in the logit and tobit models. For instance, we can see that both group membership and AI are likely to positively and significantly influence the relative probability of a household wanting to borrow as opposed to not wanting to borrow. For group members compared to non-group members, the relative risk of choosing to seek for a loan (even if they do not succeed) relative to not seeking for a loan would be greater by a factor of 1.56 given the other variables in the model are held constant. And we see that the relative risk of seeking for a loan and obtaining it relative to not seeking for a loan increases by a factor of 8.94 for group members compared to non-group members. For adopters of AI compared to non-adopters, the relative risk of seeking for credit (even if unsuccessfully) relative to not seeking for credit would be expected to increase by a factor of 1.53, other factors remaining constant. Other potentially important covariates are education of household head, age of household head, and revenue from cattle services.

The seven covariates in the multinomial logit model are used to estimate a logit model with 153 observations of households that sought for credit but did not get it and those that sought for it and got it. In the logit formulation, we create a dummy dependent variable called ACCESS that is coded 1 if a household chose to seek for

and acquired credit and 0 if a household chose to seek for credit but did not get it. Two of the covariates, namely, age of household head and revenue from cattle services are found to be highly insignificant. Eliminating the two and adding three other covariates, namely, crop revenues, revenue from cattle products other than milk, and type of feeding system produces the best fit of the logit model. We again estimate the multinomial logit model with the eight covariates of the logit model to ascertain that that the three categories of households would still be independent. The hypotheses hold.

In estimating the logit model, we are faced with an important estimation issue—the potential endogeneity of group membership and use of AI. That is, the possibility that access to credit is influenced by variables other than those included in our regression model (i.e., the error term), but which are correlated with group membership and use of AI. Another form of endogeneity is reverse causality (Verbeek 2012), whereby access to credit may enable technology adoption and participation in collective action. In this case, endogeneity arises from the fact that the error term in our structural model is correlated with access to credit, and, if access to credit influences technology adoption and collective action, then these two variables will be correlated with the error term in the structural equation. Endogeneity would lead to biased parameter estimates. Greene (2008, p. 813) observes that endogenous right-hand side variables in binary choice models are particularly problematic even when appropriate instrumental variables are available. Even more problematic is the case, such as ours, in which the endogenous variables are, themselves, binary. In this case, the instrumental variable probit model, whose alternative estimators assume that the endogenous regressors are continuous, would not be appropriate (Newey 1987). Greene (2008, p. 817) presents a “treatment effects” model that deals with this problem. A specific case of such a model is the endogenous binary-variable model described by Heckman (1978, p. 932) and whose maximum likelihood and two-step estimators are derived by Maddala (1983). The model is applicable to observational data like ours. An example of the empirical implementation of this model and interpretation of the likelihood ratio test is provided in StataCorp (2013, p. 21). The treatment regression equation (which in our case is the equation for artificial insemination/group membership) is simultaneously estimated with the outcome equation (access to credit equation) and the likelihood ratio test is of the null hypothesis that the two equations are independent. In other words, there is no correlation between the treatment errors and the outcome errors. When we apply the endogenous binary-variable model to our data, we obtain χ^2 values of 0.21 with a p value $\equiv P[\chi^2(1) > 0.21] = 0.649$ for AI, and 0.87 with a p value $\equiv P[\chi^2(1) > 0.87] = 0.350$ for group membership. Therefore, we do not reject the null hypothesis, which implies that both AI and group membership are not endogenous. This finding might be due to the fact that the study does not differentiate between production and consumption credit. If the two variables had been found to be endogenous, a similar test on other explanatory variables would have been warranted.

The results of the logit model are summarised in Table 6. The p value of 0.054 for the model’s Wald statistic of 15.30 suggests that all the slope coefficients are simultaneously not equal to zero at the 10% level of significance. Given the low incidence

Table 6 Regression results from the logit model

Variable	Coefficient	Std error	Marginal effect
EDUCATION	0.27	0.68	0.03
SEX	0.98	0.67	0.17
LAND	- 1.13*	0.64	- 0.20
GROUP	1.65***	0.63	0.20
AI	0.22	0.49	0.03
FEEDSYS	0.56	0.54	0.08
REVOTHERCAT	1.63	1.55	0.33
REVCROP	- 1.23*	0.67	- 0.13
CONSTANT	- 1.97**	0.89	
$n = 153$			
Wald $\chi^2 (8) = 15.30$			
Prob > $\chi^2 = 0.054$			
Pseudo- $R^2 = 0.133$			
Log pseudolikelihood = - 66.888			

Dependent variable is ACCESS, coded 1 = household sought for credit and got it and 0 = household sought for credit but did not get it

***, ** and *denote significance at 1, 5 and 10%, respectively

of credit, we also estimate a rare events logit model (King and Zeng 2001a, b) but obtain similar results. We find that group membership significantly increases the probability of acquiring credit. In terms of odds (antilog of coefficients), households that belong to a group are five times more likely to acquire credit than those who do not belong to a group. Estimates of marginal effects reveal that the probability of acquiring credit is 20% greater for households with group membership than for those without membership. Elsewhere, group membership was observed to be strongly correlated with greater access to credit in Zimbabwe (Bratton 1986) and Kenya (Mwangi and Ouma 2012). The effect of using artificial insemination, although positive, is insignificant in this study. This is probably because neither is constant availability of AI nor conception from it guaranteed. Failure rates of up to 50% have been reported for semen from the National Artificial Insemination Centre. This uncertainty in availability and conception seems to dampen efforts to acquire credit or the willingness to disburse it.

The odds of acquiring credit appear to decline with increase in the size of land owned by a household, *ceteris paribus*. The probability of acquiring credit for households owning more than 1 acre (c.0.4 ha) of land is 20% less than that of households with 1 acre and below. At first, this result might seem surprising but it appears to emanate from the fact that in most of the study sites, large land holdings are in most cases communally-owned, which makes them unattractive to the lender as collateral for loans to individual households. From the lender's perspective, communally-owned land as collateral might not sufficiently deter the borrower from making late repayments or completely defaulting on the loan owing to the usual problems associated with common property resources. And even if the land were in the lender's

Table 7 Tobit model regression results for amount of funds borrowed

Variable	Coefficient	Std error
INTEREST	− 162,300	242,342
SEX	207,842	1,028,076
LAND	− 2,517,828**	1,156,800
GROUP	1,804,497**	843,198
AI	904,331*	508,045
FEEDSYS	585,632	559,000
DISTANCE	945,614	708,019
REVCROP	− 1,382,869*	824,412
CONSTANT	− 743,430	1,575,832
$n = 153$		
Wald $\chi^2(8) = 19.52$		
Prob > $\chi^2 = 0.012$		

Dependent variable is LOAN

***, ** and *denote significance at 1, 5 and 10%, respectively

hands, it would be difficult for them to dispose of it in case of default because of complications of having to deal with non-borrowers' claim to the land.

Deriving income from crop sales has a negative influence on access to credit, contrary to what we posited. Nonetheless, this result is not entirely counterintuitive. Commercial crop production by milk producers is a practical income diversification strategy that is to some degree a substitute for credit in mitigating the effects of transitory income shocks arising from market and production risks. Therefore, viewing credit access from the demand side, it seems that households that obtain extra income from crop production are likely to expend less than the required effort to access credit.

The best fit of the tobit model with the dependent variable as amount of funds borrowed (LOAN) is obtained with covariates similar to those in the logit model except with education of household head and revenue from cattle products other than milk. Instead, distance of household from nearest trading centre and interest rate are included to produce the results shown in Table 7. Given that the p value of the Wald statistic (19.52) is 0.012 and is less than 0.05, all slope coefficients are jointly significant at the 5% level of significance and they represent the marginal effects of the regressors on the latent variable rather than on the loan amounts borrowed. An important estimation issue for the tobit model is the potential endogeneity of interest rates. To resolve the issue, we use Newey's (1987) efficient two-step minimum χ^2 estimator to estimate a structural equation for amount of funds borrowed and a reduced form interest rate equation. The resulting Wald test of the null hypothesis that interest rates are not endogenously determined produces a χ^2 statistic of 1.59 with a p value of 0.207. Therefore interest rates are not endogenous.

That interest rates are exogenous is plausible in the Tanzanian context. Interest rates were liberalised in the early 1990s, and nearly 60% of the indebted households

in the sample had acquired their loans from formal private micro-credit banks,¹ whose rates are likely to be similar for all borrowers. Endogenously determined interest rates are usually evident where the rural credit market is characterised by moneylenders, who use their detailed knowledge of the repaying capacity of different borrowers to charge different interest rates. Although interest rates are found to be exogenous, nonseparability of production and consumption loans would still hold because of the subsistence nature of production, the fungibility of credit, and the likelihood that savings rates among these households vary with income and other factors. Interestingly, the effect of interest rates on access to credit is statistically insignificant. A similar result was found by Atieno (1997) for Kenya and Diagne (1999) for Malawi. The importance of this variable warrants an explanation of this seemingly contradictory result. It has been argued that, in low-income countries, access to credit in rural areas is more affected by several other factors than it is by interest rates (Desai and Mellor 1993). A possible explanation that derives from our data is that amounts borrowed include consumption credit, which, if obtained for purposes such as school fees, medical care and other emergencies, is unlikely to be significantly responsive to changes in interest rates. From the production loan perspective, Hoff and Stiglitz (1990) noted that an increase in the interest rate would simply change the borrower's mix of projects in favor of the more risky ones, which provide higher expected net returns.

The coefficients on group membership and use of AI are positive and statistically significant, as expected. So, whereas use of AI does not increase the chances of a household obtaining a loan, the costs associated with its adoption increase the amount that a household would borrow. A model capturing interactions between group membership and AI use was estimated but did not show statistically significant interactions. Consistent with the logit model, coefficients on land holding and crop revenues are negative and significant. We do not find a gender effect, a result consistent with results from the multinomial logit and binary logit models, as well as findings by Weber and Musshoff (2012) on access to credit in Tanzania.

Coefficients of a tobit model can be interpreted in a manner similar to those of a model estimated by ordinary least squares, but the effect would be on the uncensored latent variable not on the observed variable. The marginal effect of a given explanatory variable on loan amounts borrowed can be calculated by multiplying the estimated coefficient by an adjustment factor; however, the two-step estimator does not specify the adjustment factor (Li 2008). Nonetheless, the effect on the observed variable would be smaller than that on the latent variable.

¹ Of the households that held membership in a group, 16% were members of SACCOS, which disburse loans to individual members. There were no micro-credit banks in the study area undertaking group (solidarity) lending or that required a prospective borrower to be a member of a group. The authors were involved in implementing a research for development project that aimed to facilitate the creation of linkages between lenders and milk producers. Consequent to the project's interventions, banks such as Covenant Bank for Women (Tanzania) Ltd and Tanzania Agricultural Development Bank Ltd began to show interest in group lending in the study area.

Summary and Concluding Remarks

This study has attempted to provide an understanding of the effect of collective action and technology adoption on access to credit using the example of milk producers in Tanzania. The analysis is undertaken sequentially to systematically examine the effect of the two variables. It begins with a multinomial logit model of three categories of households: those that did not seek credit, those that sought but did not acquire credit, and those that sought and acquired credit. We find that households that did not seek credit are distinct from those that sought but did not acquire credit. Subsequently, we examine the decision to borrow using a binary logit model, and estimated the determinants of amount of funds borrowed using a tobit model. We found that the incidence of borrowing is only 7%, which is far less than what has been found in rural communities in other East African countries. We also found that collective action increases both the probability of acquiring credit and the amount of funds borrowed, whereas technology adoption only increases the amount of funds borrowed.

Our findings have two major policy implications. First, public policy for increasing rural households' access to credit should support public and private sector investment in collective action. However, this recommendation needs to be examined further because it raises the question as to why it is that SACCOS, which are in fact characterised by collective action and have been supported by the Tanzanian government in terms of policy, have not considerably increased access to credit among livestock keepers. Certainly, this question is beyond the scope of this study, but it does suggest a degree of caution in promoting collective action as a means to achieving greater access to credit. In this study, only 16% of the households are members of SACCOS compared to 77% that belong to livestock producer groups. It might well be that, for collective action to be effective, homogeneity of group members is important, as was the case for the success of rotating savings and credit associations in Cameroon (Hoff and Stiglitz 1990). In addition, collective action in SACCOS is usually predicated on the ability of cooperatives to mobilise savings from members, and the ability to mobilise savings has been found to enhance outreach by microfinance institutions (Hartarska and Nadolnyak 2007). In Tanzania, however, the share of livestock in total household income is only 13% (Covarrubias et al. 2012), implying that savings from livestock income have perhaps been too low to support the formation of livestock-based SACCOS. It could also be that livestock keepers in Tanzania, most of whom live in remote and marginal areas, are not accustomed to formal savings arrangements, in which case a commitment savings product like one designed and implemented by Ashraf et al. (2006) could be introduced to them.

Second, since households that benefit from collective action and technology adoption tend to borrow more, public investments should not only support technology adoption and collective action but should also support other factors that improve the supply of credit. This is because, at a higher level of demand for funds, interest rates might increase and become significant, if not usurious. Consequently, there could be credit rationing at the new equilibrium. To the extent

that technology adoption and collective action reduce the risk of default and lenders' transaction costs, the scope for public policy intervention might include influencing the structure of the credit market to ensure free entry of lenders into the market, and reducing the opportunity cost of their funds. Prospective lenders might benefit from information such as that in Twine et al. (2018) on the riskiness of milk production in Tanzania.

A key conclusion from the empirical modelling standpoint is that, in a study like this, there is a possibility that households that did not seek credit in the study's reference period are actually credit-constrained, but decided to exclude themselves from participating in the credit market because of past unsuccessful attempts to borrow. Such households should be distinguished from those that did not seek for credit because they did not need it, and how to account for them in studying access to credit is an area for further research that would complement our approach as well as the constraint elicitation method (Boucher et al. 2009) pioneered by Feder et al. (1990).

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