Credit, Technology Adoption and Collective Action in Tanzania's Smallholder Dairy Sector

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ABSTRACT

The study investigates the role of technology adoption and collective action in the demand for credit among dairy farmers in rural Tanzania. Using survey data from four districts in Tanga and Morogoro regions, the incidence of credit is found to be seven percent. Logit and tobit models based on a conceptual framework that assumes endogenously determined interest rates and nonseparability of production and consumption credit, are applied to the data. Interest rates are found to be exogenous and statistically insignificant in the demand for credit. The logit model shows collective action to positively influence the decision to borrow, but technology adoption is insignificant. From the tobit model, both collective action and technology adoption positively influence the amount of funds borrowed. We use these results to examine the observed failure of rural savings and credit cooperative societies to lend to smallholder dairy farmers and livestock keepers in general in Tanzania.

Keywords: Credit, technology adoption, collective action, smallholder dairy farmers, Tanzania

JEL codes: Q13, Q14, Q16

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1. Introduction

The importance of credit in agricultural and rural transformation in developing countries is widely acknowledged. Credit played a significant role in the adoption of improved agricultural technologies during the Green Revolution (Jabbar, Ehui and Von Kaufmann 2002). In Tanzania, access to credit has positively influenced adoption of crossbred-cow technology (Abdulai and Huffman 2005) and in Kenya and Ethiopia, credit has been observed to increase milk production when used to finance investment in cross-bred dairy cows (Freeman, Ehui and Jabbar 1998). Recently, Swaminathan, Du Bois and Findeis (2010) find that the likelihood of participation in off-farm work in Malawi increases with access to credit, while Jia, Xiang and Huang (2013) have found that access to microfinance significantly increases time allocated to off-farm self-employment in rural China. Participation in collective action and formation of social capital have also been found to benefit from access to credit (Fischer and Qaim 2012; Shoji et al 2012). Credit enables consumption smoothing, investment in off-farm income generating activities, and it can be used to cope with income shocks. Numerous studies such as those highlighted above have investigated the impact of credit on important drivers of rural transformation in developing countries, but the possibility of the reverse effect has received far less attention in the literature. This paper attempts to fill this gap.

Credit rationing, which can occur even in equilibrium (Stiglitz and Weiss 1981) and missing markets for credit remain significant challenges to agricultural and rural transformation. Ali and Deininger (2012) cite literature that has pointed to lack of access to credit by farmers as a key impediment to achieving higher levels of productivity in developing country agriculture. For smallholder farmers, lack of access to credit can be attributed to asymmetric information, which

is further compounded by inadequate or risky collateral, uncertainties associated with subsistence agricultural production, and high transaction costs. These factors have contributed to the low demand for and supply of both formal and informal credit in rural Tanzania (Mohamed 2003; Salami, Kamara and Brixiova 2010), especially after the collapse of most cooperative unions following the liberalization of the country's financial sector in the 1990s (Rweyemamu, Kimaro and Urassa 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), only 6% of livestock keeping households have been found to have had membership in these cooperatives and unsurprisingly, only the same proportion has held credit (Covarrubias, Nsiima and Zezza 2012). Moreover, participation in informal savings and credit schemes such as the rotating savings and credit associations (ROSCAs) was found to be as low as 4.3% in the Kilimanjaro region (Kimuyu 1999). The government of Tanzania recognizes 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 it rural development strategy (United Republic of Tanzania 2001).

Although the incidence of credit among rural households in Tanzania is currently low, the government's efforts towards rural transformation are likely to gradually increase demand for credit. Indeed, technological and institutional strategies such as technology adoption and collective action that have become characteristic of rural transformation in low-income countries have been observed to impact the demand for credit. Iqbal (1983) has found technology adoption to unambiguously increase the demand for credit in rural India, while Okten and Osili (2004) find that participation in community networks enhances individuals' access to credit in

Indonesia. Both technology adoption and farmer collective action are currently being supported by the Tanzanian government and its development partners and therefore it is imperative to understand the responsiveness of demand for credit to the two development strategies so as to allocate sufficient resources to potential rural credit schemes.

This paper undertakes an empirical analysis of the demand for credit by dairy farmers in rural Tanzania. It estimates the incidence and level of demand for credit in intensive and extensive cattle feeding systems, and determines the effect of technology adoption, specifically the use of artificial insemination, and collective action on the decision to obtain credit and on the amount of credit obtained. The paper is organized as follows: section two provides an overview of rural financial service delivery, dairy cattle technologies and collective action in Tanzania. Section three summarizes related literature and section four presents the data and descriptive statistics. Section five describes the conceptual framework and empirical models, section six discusses the regression results and section seven concludes the paper with remarks on SACCOS and implications for rural microfinance initiatives.

2. Rural credit, dairy cattle technologies and collective action in Tanzania

Delivery of financial services in rural Tanzania

Provision of financial services to households and enterprises in rural Tanzania has remained underwhelming in spite of the decentralization reform implemented more than four decades ago, the existence of demand for the services among rural households as revealed by Amani et al (1987), and the financial sector reform initiated in 1988, which included recapitalization of the Cooperative and Rural Development Bank (CRDB). When the government began implementing decentralization reform in 1972, it was evident that banks and other financial institutions would not easily decentralize their operations, hence the formation of

the Regional Development Fund (RDF) that offered loans to small-scale enterprises (Maro 1990). But formal and informal financial markets for rural households remained undeveloped relative to other African countries; between 1985 and 1989, 90% of all private loans to rural areas went to government parastatals and cooperatives, and the lending that went to farmers was mostly in-kind (Dercon 1998). For instance, cooperative unions such as those organized around coffee processing and marketing often provided credit in-kind in form of production inputs such as pesticides. Credit dues were then checked-off the unions' payment to indebted farmers. Interlinking credit with farmers' output ensured that credit was solely applied to production decisions (Kimuyu 1999). Cash loans taken by farmers were mostly informal loans obtained from relatives and friends (Amani et al 1987).

Wangwe and Lwakatare (2004) provide a detailed description of the financial sector reform in Tanzania. Before the reform, CRDB and the National Bank of Commerce (NBC) provided most of the formal rural financial services. Loans were allocated administratively and mostly to cooperatives. But challenges in managing the banks and their clients – cooperatives and parastatals – coupled with high default rates caused the banks to have large non-performing loan portfolios. By 1988, the two banks had become unprofitable. The financial sector was effectively reformed in 1991 by liberalizing interest rates, restructuring banks and privatizing some of them. In the same year, cooperatives were restructured through the Cooperatives Act of 1991, which also allowed for the establishment of SACCOS. Also, non-government micro-credit institutions came into existence. The National Micro-Finance Policy of 2000 governs the provision of rural financial services and the Cooperative Development Policy of 2002 supports the implementation of the National Micro-Finance Policy insofar as cooperatives, including

SACCOS, are expected to be an important channel through which financial services are to be provided to rural households.

At present, provision of rural financial services is undertaken by five types of institutions, namely, commercial banks (e.g., CRDB), cooperatives, non-government organizations (e.g., PRIDE, FINCA), government organizations (e.g., SIDO), and private agro-processing companies (e.g., Tanzania Breweries Ltd.) that are vertically linked to smallholder farmers through contract farming. Although these institutions have somewhat succeeded in deepening financial services in rural areas (Wangwe and Lwakatare 2004), impediments to increased demand for credit such as high interest rates, lack of adequate collateral, and poor infrastructure have persisted. This study considers these and other factors in estimating demand for credit.

Dairy cattle technologies

For over a century, the Tanzania Livestock Research Institute (TALIRI), under different names, has steered research and dissemination efforts on various dairy cattle technologies that are relevant to three critical issues: animal health, feeding, and breeds and breeding. In the 1920s, emphasis was on the production of vaccines for the treatment of rinderpest and trypanosomiasis, and in the 1930s, research on animal feeding began. This was followed by animal breeding activities in the 1940s after the Institute had introduced exotic dairy cattle breeds in the previous two decades. Some of the results of the Institute's endeavors have included development and distribution of improved pastures such as Ex-Mpwapwa Rhodes grass and the dual purpose Mpwapwa cattle breed, as well as increasing the milk production potential of the indigenous Tanzania short-horn zebu (TSZ) cattle through cross-breeding with Mpwapwa, Sahiwal, Red sindhi, Ayshire, and Boran breeds (Ministry of Livestock and Fisheries Development 2011). Through the livestock sector development programme (LSDP), the

government is working towards increasing a) pasture seed production at its eight pasture seed farms from the current 45 tons per year to the estimated annual demand of 300 tons; b) production of compounded feedstuffs; c) availability of dairy cattle breeds through artificial insemination; and d) options for preventing and controlling the spread of cattle diseases and parasites.

A few studies have analyzed adoption of dairy cattle technologies in Tanzania. Rushalaza and Kasonta (1992) report on the *Improvement of Livestock Production Systems in Semi-arid Central Tanzania* – an IDRC-funded research project implemented from 1983 to 1986 in Mpwapwa district, Dodoma region. The purpose of the project had been to evaluate the adoption and on-farm performance of several technologies including the Mpwapwa cattle breed, improved pasture species, dual-purpose legumes, intensive feed gardens, cereal stovers and other crop residues, and water (fodder) melon (*Citrullus vulgaris*). It was found that all technologies had been adopted by farmers, albeit to varying degrees. Kaliba, Featherstone and Norman (1997) investigate factors influencing the adoption of stall feeding for improved dairy cattle and associated technologies (bitter water melon for cattle feeding and intensive feed gardens). They find that households that are likely to adopt stall feeding and associated technologies are those that are resource-constrained. Abdulai and Huffman (2005) find that besides access to credit, adoption of cross-bred cattle is positively influenced by proximity of a farmer to a farm with crossbreed cattle, level of formal education and use of extension services. From data collected in late 2012 and early 2013, Njehu and Omore (2014) find that less than 20% of households in Tanga and Morogoro regions reported the availability of artificial insemination services and even a much smaller proportion reported having used the services in the previous year. An earlier report pointed to the inability of the industry to support private artificial insemination services

(Zylstra, Lyimo and Rutamu 1995). Our study is undertaken in the same regions to enable us control for the influence of the different cattle feeding systems.

Collective action

Collective action in Tanzania dates back to the formation of the Kilimanjaro Native Planters Association in 1925 and the enactment of the first cooperative legislation, the Cooperatives Ordinance of 1932 (United Republic of Tanzania 2005). However, after the country's independence in 1961, cooperatives became instruments of the government's social and economic policies and therefore deviated from their cardinal objective of maximizing members' welfare. Inevitably, most cooperatives collapsed and the cooperative movement was abolished in 1975, only to be reinstated in 1984. Several initiatives including the 2002 Cooperative Development Policy and its legal framework, the 2003 Cooperative Societies Act, as well as the Cooperative Reform and Modernization Program implemented from 2005 to 2015 have been undertaken to revive cooperatives. Alongside this revival has been the emergence of community-based farmer (producer) groups/organizations that are registered with their respective local government's department of community development.

Cooperatives and farmer groups have been active in the Tanzanian dairy industry (De Wolf 1995; Zylstra, Lyimo and Rutamu 1995; Kurwijila 1995; Land O'Lakes, Inc. 2007), especially in collective bulking and selling of milk. The largest dairy processor in the country – Tanga Fresh Ltd – is partly owned by Tanga Dairies Cooperative Union (TDCU), which is comprised of more than ten primary cooperative societies, whereas the second largest processor – ASAS Dairies Ltd – procures milk from dairy farmer groups and not from individual dairy farmers. At the industry level, individual milk producers and about fifty one dairy farmer groups

constitute the Tanzania Milk Producers Association (TAMPRODA), which works to protect and advocate for members' interests.

The ability of farmer groups in Tanzania to improve their marketing performance has been investigated by Barham and Chitemi (2009). From an analysis of a sample of 34 farmer groups in the North-Eastern highland area that participated in the Agricultural Marketing Systems Development Programme (AMSDP), the authors conclude that strengthening the internal structures of groups, the groups' market (entrepreneurship) skills and linkages with other value chain actors would improve marketing performance, especially for groups endowed with basic natural assets such as reliable water sources. Also noted is that improving marketing performance is a function of time and may require accumulation of financial capital through, for instance, rotating credit schemes. We draw upon this observation in developing our conceptual framework.

3. Related literature

There are two common strands of literature on demand for credit; one strand has dealt with household access to credit, defined as a household's ability to participate in the credit market, while the other has dealt with the outcome of that participation in the form of loan amounts borrowed by households. If a household needs credit, its ability to access it will be manifested in its decision to borrow. This can be analyzed with probability models of the binary response type (see, for instance, Guirkinger 2008; Fatima 2009; Giné and Yang 2009; Pal and Laha 2015; Yuan and Xu 2015). Some studies have analyzed the two aspects of demand for credit; Swain (2007) applies type 3 tobit and double hurdle models to Indian data, Mpuga (2008) applies probit and tobit models to Ugandan households, and Khoi et al (2013) applies the

conditional recursive mixed process – a combination of tobit, probit and Heckman two-step models – to households in the Mekong River Delta in Vietnam.

A survey of some of the earlier theoretical and empirical literature on demand for credit is provided by David and Meyer (1979). They observed that single-equation loan demand models applied to cross-sectional data had typically been used to estimate loan demand relationships in low-income countries. This appears to have remained the case in more recent literature (e.g. Atieno 1997; Swain 2007; Rahji and Ajani 2007; Briones 2009), and the theoretical model formulated by David and Meyer (1979) has generally informed the choice of explanatory variables in most empirical studies in both strands of literature. These variables have included interest rate, 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 socio-economic factors.

What is rather surprising, however, is the dearth of studies that have explicitly incorporated technology adoption and collective action in the analysis of credit demand. For instance, Iqbal (1983) alludes to irrigated land or land under improved seed varieties as potential proxies for a household's investment opportunities in the credit demand function, yet the proportion of irrigated land is used as a proxy for soil quality in his empirical model for rural India. One attempt to include both variables is by Clar de Jesus and Cuevas (1988). They find the proportion of irrigated land to increase the demand for credit in the Philippines, but surprisingly, the effect of membership of a household in a farmer organization is negative, contrary to *a priori* expectation. Membership in a farmer organization has been observed to be strongly correlated with greater access to credit and a lower likelihood of default in Zimbabwe (Bratton 1986).

A study that is somewhat similar in spirit to our study is by Jabbar, Ehui and Von Kaufmann (2002). The study analyzes demand for credit among smallholder dairy producers in Ethiopia, Uganda and Kenya, but unlike our study, it also assesses the supply of credit to smallholder livestock producers in Ethiopia, Uganda and Nigeria. All farmers surveyed in Ethiopia, Uganda and Kenya were found to use one or more improved dairy cattle technologies including crossbred or purebred exotic animals, artificial insemination, 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 adoption of one technology – improved dairy breeds (captured as 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.

Given the paucity of studies analyzing the effect of technology adoption and collective action on credit demand and the lack of consensus among the few that have attempted to do so, we draw upon existing conceptual notions to pursue the subject further for the case of Tanzania. Our empirical methods are straightforward; consistent with previous studies, we use the logit model to estimate the determinants of the decision to borrow. But because of the particularly low incidence of borrowing among cattle keepers in Tanzania, we also apply the rare events logit model proposed by King and Zeng (2001a; 2001b). We use the tobit model, which takes into consideration the censored nature of our sample, to estimate the determinants of credit demand.

4. Data and descriptive statistics

The study is based on a stratified sample of 461 cattle keepers in Lushoto and Handeni districts in Tanga region, and Kilosa and Mvomero districts in Morogoro region. The survey was

undertaken from July to September 2014. Data was collected on several variables and summary statistics of those used in the regression analysis are presented in table 1. From the data, districts are categorized by the predominant feeding system; Lushoto district is dominated by the intensive feeding system, while Handeni, Kilosa and Mvomero districts are dominated by the extensive feeding system. We now examine in detail and by district the three variables of interest to this study: credit demand, dairy farming technologies and practices, and collective action.

Demand for credit

Overall, 33% (152) of the households had wanted credit in the six months prior to the survey, and of these, only 20% had been able to acquire it. Considering the entire sample, the incidence of borrowing among cattle keepers is about 7%, which is as low as the 6% obtained for livestock keepers nationally from the National Panel Survey data of 2008/2009. These figures are much lower than the figures obtained by Jabbar, Ehui and Von Kaufmann (2002) for Ethiopia, Uganda and Kenya. The need for credit was highest in Mvomero district (46%) followed by Lushoto (35%) as shown in table 2. Local microfinance institutions including savings groups provided the bulk of the loans, with land and livestock being the most common forms of collateral.

Use of dairy farming technologies

Use of dairy cattle technologies was investigated by eliciting responses to questions on fodder production and use, and use of animal health and breeding services. Fodder production and use is strongly correlated with feeding systems. Overall, only 33% of the households surveyed grow fodder. Data shows that 94% of the households in Lushoto grow fodder compared to 7%, 1%, and almost none in Mvomero, Handeni and Kilosa, respectively. The proportions of households growing the different types of fodder are shown in table 3. Napier grass is the most

widely grown fodder in Lushoto and Mvomero, but is hardly grown in Handeni. Instead, other grasses such as Guatemala and Fen grass are grown in Handeni. About 90% of farmers grow fodder on the edges of their farmland, while the remaining 10% have specific plots for it.

Table 1: Summary statistics of variables used in the regression analyses

Label	Description	Mean	S.D.	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 (Tz Shillings)	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
GENDER	Gender of household head (1 = female; 0 = male)	0.09	0.29	0	1
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	2,280
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
INCOMECAT	Household income from cattle sales last 6 months (Tz Shillings)	503,562	1,453,470	0	2.05E+07
INCOMEOTHERCAT	Household income from other cattle products (Tz Shillings)	24	269	0	5,000
INCOMECATSERV	Household income from cattle services (Tz Shillings)	6,356	60,001	0	1,000,000
INCOMECROP	Household income from crop sales in last 6 months (Tz Shillings)	110,723	956,135	0	2.0E+07
INCOMEOTHER	Household income from other sources (Tz Shillings)	349,184	1,235,116	0	1.0E+07

N=461 except for *AGE* (459), *DISTANCE* (456), *LOAN* (31) and *INTEREST* (31).
Income was obtained from the six months preceding the survey.
Tz denotes Tanzanian

Table 2: Households that needed and obtained credit

District	N	Number of households that needed credit	Number of households that obtained credit	Households that needed credit (%)	Households that obtained credit as a percentage of those that needed it (%)
Lushoto	154	54	14	35	26
Mvomero	98	45	12	46	27
Handeni	105	29	3	28	10
Kilosa	104	24	2	23	8

Table 3: Households growing fodder

District	N	Number growing fodder	Napier grass (%)	Planted grasses (e.g., Rhodes grass) (%)	Fodder shrubs (e.g., Sesbania) (%)	Other (%)
Lushoto	154	145	70.3	26.2	0.7	2.8
Mvomero	98	7	71.4	14.3	14.3	0.0
Handeni	105	1	0	100	0	0
Kilosa	104	0	0	0	0	0

Reasons for not growing fodder were examined. Majority of the farmers in Mvomero (76%), Handeni (62%) and Kilosa (81%) pointed to lack of knowledge on fodder production. The few in Lushoto that did not grow fodder claimed to be short of both knowledge and land. Roughly 35% in Mvomero, 19% in Handeni and 27% in Kilosa also cited lack of land. Limited labour seemed to be a constraint for about 20% of farmers in Mvomero and 22% in Kilosa. In sum, limited knowledge, land and labour appear to be the most important constraints to fodder production. Moreover, buying fodder does not appear to be an option for most farmers. For instance, most of the farmers that purchased fodder live in Lushoto and are less than 20% of the total number of farmers interviewed from the district. Considering the total sample size, only 7% buy fodder.

The survey sought to determine the extent of use of other types of fodder, namely, crop residues and concentrates. Overall, crop residues are used by about 30% of farmers and are usually obtained from the farmers' own fields. Only 18% of farmers buy crop residues. Crop residues are commonly used in Lushoto, but to a lesser extent elsewhere. Sixty six percent of

farmers in Lushoto use crop residues, especially maize stover (used by 94% of farmers) left in the fields after harvest, compared to 14% in Mvomero, 15% in Handeni and a mere 3% in Kilosa. What is clear from the above results is that planting fodder and use of crop residues is more prevalent among cattle keepers that also grow crops. Cattle keepers that do not grow crops are unlikely to plant fodder because they may not have sufficient knowledge of the agronomy of extant fodder species. Indeed it is not surprising that lack of knowledge was reported to be a critical constraint to fodder production.

Use of (different types) of concentrates is reported in table 4. Of the total households surveyed, 26% use concentrates. Again, Lushoto has the highest percentage (62%) of households using concentrates, whereas the incidence of concentrate use in other districts is relatively low. This is expected given the differences in feeding systems across districts. Bran appears to be the most popular supplement in all districts and is commonly procured from millers, although agro-vets and market traders too are a fairly important source of concentrates.

Table 4: Households using the different types of concentrates

District	N	Households using concentrates (%)	Bran (maize, wheat) (%)	Mineral block (%)	Oilseed by-product (%)	Maize germ (%)	Commercial dairy meal (%)
Lushoto	154	61.7	96.8	15.8	5.3	5.3	4.2
Mvomero	98	20.4	95.0	20.0	20.0	0.0	0.0
Handeni	105	5.7	50.0	66.7	16.7	0.0	0.0
Kilosa	104	1.0	100.0	0.0	0.0	0.0	0.0

Regarding animal health practices, we consider availability and frequency of use of deworming, tick control, vaccination and curative treatment services. The most available animal health services appear to be tick control (as reported by 66% of households) followed by deworming services (59%), and curative treatment (32%). The least available are vaccination services; only 11% of the households interviewed reported the services to be available in their

villages. From table 5, it is evident that deworming is quite common in Lushoto, Mvomero and Handeni, while tick control is common in Mvomero, Handeni and Kilosa. To analyze the statistics in a more informative way is to note that 82% of farmers in Kilosa reported the absence of deworming services and 62% in Lushoto reported the absence of tick control services. In fact most farmers in Kilosa did not deworm their cattle in the six months prior to the survey, and farmers in Lushoto used some form of tick control only four times on average compared to, say, 34 times for farmers in Kilosa (table 6). Services for curative treatment of diseases appear not to be widely available in all districts, but even more so are vaccination services. To fully comprehend the significance of lack of animal health services requires knowledge of the prevalence and incidence of cattle disease in the four districts.

Table 5: Households reporting availability of animal health services

District	N	Deworming (%)	Tick control (%)	Vaccination (%)	Curative (%)
Lushoto	154	81.8	37.7	22.1	18.8
Mvomero	98	72.4	82.7	3.1	35.7
Handeni	105	55.2	70.5	10.5	43.8
Kilosa	104	18.3	88.5	2.9	33.7

Table 6: Frequency of use of animal health services

	Deworming			Tick control			Vaccination			Curative		
District	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Lushoto	125	1.3	0.8	57	3.7	5.6	34	0.8	0.5	29	1.1	1.0
Mvomero	71	1.2	1.5	81	18.8	23.7	2	6.5	7.8	28	1.0	1.4
Handeni	57	1.0	1.7	74	10.0	7.6	11	0.3	0.5	42	2.2	3.9
Kilosa	19	0.6	0.6	92	34.2	39.8	3	0.0	0.0	34	3.1	4.4

We find that most farmers in all districts do not discriminate among the different types of cattle (cows, bulls, bull calves and heifers) with respect to the various animal health practices. This is expected and is probably because of the unique nature of (all types of) cattle as consumption and capital goods, the fact that their monetary value is expected to increase with weight gain, and the likely spread of parasites and infectious diseases including zoonotic

diseases. These three factors imply that discrimination in the prevention and treatment of diseases among cattle types would reduce the profitability of cattle keeping in general. On the one hand, cattle are consumption goods insofar as they can be consumed without further transformation. This means that if a farmer is to get the best price from the sale of any of their animals for immediate slaughter at any given age, the animal ought to be in the best possible state of health. On the other hand, cattle are capital goods in the sense that they can be used in the production of other goods (including more cattle) and services. Therefore besides the farmer's investment decisions, the health of the entire herd in the current period will determine the health of the herd in the subsequent period(s). Also, irrespective of the type of cattle, the animal's weight is usually positively correlated with its sale price. It is reasonable to expect cattle keepers to be aware that parasites and diseases increase the cost of gain (i.e., the cost of raising the weight of an animal by one unit) thereby undercutting the profitability of their enterprises. The loss of profitability would be exacerbated by the non-discriminatory nature of some parasites and diseases. Therefore it would be in the farmer's best interest to control parasites and diseases in the entire herd rather than among specific categories of cattle.

An analysis of the sources of animal health services and the availability of expertise for delivery of the services shows that over 50% of farmers in each district deworm their animals themselves with the help of some advice from people knowledgeable about the practice. Likewise, majority of farmers in each district administer tick control measures themselves. Therefore it appears that farmers in all districts are generally confident in their ability to deal with external and internal parasites. But there are variations in sources of vaccination and curative treatment services: in Lushoto, most farmers obtain vaccination and treatment services from government veterinarians, whereas majority from Mvomero vaccinate and treat the animals

themselves. In Handeni, vaccination is either administered by farmers with or without external help or by government veterinarians, while most farmers in Kilosa treat their animals themselves, although a significant proportion uses agro-vet shop owners.

We now compare the use of three breeding methods, namely, artificial insemination (AI), use of farmer's own bull, and use of other bulls not owned by the farmer. We find that overall, 31% of all households use AI, while 69% and 45% use their own bulls, and other farmers' bulls, respectively. Close to 60% of farmers in Lushoto use AI, while 34% and 55% use own bull and other bulls, respectively. In Mvomero, Handeni and Kilosa, a relatively small number of farmers use AI, but over 80% use their own bulls, and over 34% use other bulls too, as shown in figure 1. Preference for AI in Lushoto was attributed to *inter alia*, the service being readily accessible, its high success rate, and the wide variety of breeds that can be acquired through it. Regarding use of own bulls and other bulls, farmers pointed to availability of the bulls and a high success rate. Public and private AI providers are the main sources of AI services, followed by cooperatives.

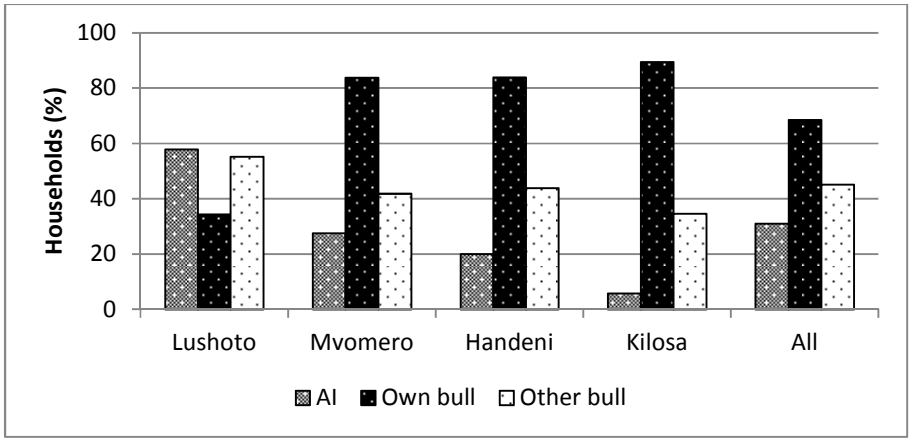

Figure 1: Percentage of households using AI, own-bulls and other bulls

In summary, the use of dairy farming innovations in the study areas is not extensive; the proportion of households using different types of fodder is at most 30% in spite of the widespread seasonality of pasture, and the proportion using AI is 31% in spite of the lack of high

milk-yielding cattle. Regarding the extent of use or adoption of animal health practices, however, meaningful inferences can only be made by taking into consideration information on the incidence and importance of cattle diseases in the study areas. Currently, this information is, at best, anecdotal.

Membership in farmer groups

Membership in one or more groups was obtained by gender of participants and type of group. Overall, almost half (47%) of the surveyed households have at least one member participating in a group (table 7). The lowest participation is in Kilosa (37%), while the highest is in Mvomero (58%). More men (74%) participate in farmer groups than women (40%). Membership in groups in Handeni and Lushoto was almost the same at 47% and 48%, respectively.

Table 7: Group membership by gender

District	N	Households with a member in a group (%)	Households with a man as member (%)	Households with a woman as member (%)
Lushoto	154	48.1	75.7	44.6
Mvomero	98	58.2	68.4	45.6
Handeni	105	46.7	77.6	34.7
Kilosa	104	36.5	76.3	26.3

Regarding membership in different types of groups, livestock groups had the largest number of households across the four districts (table 8). This is not surprising because the survey targeted cattle keepers. Overall, more than three quarters (77%) of households with at least a member participating in a farmer group belong to a livestock producer group.

Table 8: Household membership by group type

District	Social welfare group (%)	Savings and credit group (%)	Agricultural producer group (%)	Livestock producer group (%)	Agricultural marketing group (%)	Livestock marketing group (%)
Lushoto	9.5	20.3	8.1	74.3	4.1	20.3
Mvomero	5.3	22.8	0	75.4	1.8	1.8
Handeni	2	14.3	12.2	69.4	6.1	20.4
Kilosa	0	0	7.9	92.1	0	15.8

Kilosa has the highest participation at 92%. Participation in savings and credit groups (e.g., SACCOS) and in livestock marketing groups is estimated to be 16% and 15%, respectively. The relatively low participation in non-livestock groups may be an indicator of the relative importance of livestock and livestock-related activities as livelihood sources in the study areas.

5. Conceptual framework and empirical models

To conceptualize the factors that affect demand for credit, we assume that a household facing two time periods maximizes utility subject to budget and time constraints. The household borrows in the current time period, for both production and consumption, and repays the loan in the second time period. According to David and Meyer (1979), under certain conditions such as perfect financial markets and fixed savings rate, production and consumption decisions are separable. Because interest rates are exogenous, the household's optimal production will occur where the marginal rate of return on investment is equal to the interest rate, while optimal consumption will occur where the market opportunity line[1] is tangent to the highest utility curve. The demand for credit will then be a function of interest rate, the household's investment opportunities, and its time-preference between current and future consumption, which depends on, among other things, the household's characteristics. However, in low-income countries such as Tanzania, financial markets are likely to be imperfect. Moreover, the subsistence nature of production means that production and consumption decisions are necessarily intertwined, implying that disregarding the fungible nature of credit, a 'production' loan may well be considered a 'consumption' loan and vice-versa. Given imperfect financial markets, optimal

[1] This is an iso-wealth line (on a graph of future consumption against current consumption) representing constant present value of wealth for the household (Trigeorgis 1996).

levels of production, consumption and borrowing will be determined simultaneously, hence a concave market opportunity line. As such, it is difficult to formulate separate demand functions for production and consumption credit.

In order to integrate production and consumption decisions in the demand for credit, we specify a model of an imperfect financial market in which interest rates are endogenously determined by variables related to the ability of the household to avoid default. We begin by examining the decision to borrow using the framework in Swain (2007). The credit access functions are such that:

$$CREDIT^* = X\beta + \varepsilon_c \quad \text{..... (1)}$$

$$ACCESS^* = Z\delta + \varepsilon_a \quad \text{..... (2)}$$

where $CREDIT^*$ is the latent variable for credit and $ACCESS^*$ is the latent variable for access to credit, X and Z are matrices of regressors, β and δ are vectors of parameters, and ε_c and ε_a are vectors of disturbance terms. Credit will be a market outcome if a household has positive demand for it and is able to access it. Formally, this can be represented by the probability:

$$\Pr[CREDIT^* > 0; ACCESS^* > 0] \text{ ..... (3)}$$

The probability of borrowing is estimated with a logit model. Using the latent-variable formulation in equation (1), the variable *CREDIT* is an indicator for whether or not the latent variable $CREDIT^*$ is positive. That is, *CREDIT* = 1 if $CREDIT^* > 0$ and *CREDIT* = 0 if $CREDIT^* \leq 0$. Because of the rarity of holding credit among the sample households, we also employ a variant of the logit model, the rare events logit model (King and Zeng 2001a; 2001b),

which is intended to overcome the finite-sample bias in logit estimates that is amplified by the rare nature of the event[2] (i.e., borrowing). Results of the two models are compared.

Estimating the determinants of the amount of credit obtained generally follows the approach in Iqbal (1983), Clar de Jesus and Cuevas (1988) and Swain (2007). The censored nature of our sample warrants the use of the tobit model. Formally, demand for credit, $LOAN^*$, is a latent variable:

$$\begin{aligned} LOAN^* &= X\phi + INTEREST\ \varphi + u \\ INTEREST &= X\gamma_1 + W\gamma_2 + v \end{aligned} \quad \text{…….. (4)}$$

where ϕ and φ are vectors of structural parameters, W is a vector of additional instruments and therefore the interest rate equation is written in reduced form, γ_1 and γ_2 are matrices of reduced-form parameters and u and v are vectors of disturbance terms. The observable loan amount borrowed, $LOAN = LOAN^*$ if $LOAN^* > 0$ and zero otherwise. We estimate equation (4) using Newey's (1987) efficient two-step minimum chi-squared estimator. Controlling for cattle feeding system and other variables, we expect the effect of interest rate to be negative.

The use of AI and membership of a household in a farmer group or any other self-help group are expected to increase both the probability of borrowing as well as the amount of funds borrowed. From the survey data, the average cost of a single AI service in all districts was found to be 14,615 Tanzanian Shillings[3], and majority of farmers in the extensive feeding system found it to be expensive relative to other breeding methods. Another possible reason for the positive effect is that the use of AI may in turn lead to the demand for different and more expensive types of inputs – hence increased demand for funds – as the proportion of crossbred cattle in the

[2] A rare event dummy dependent variable is such that ones are dozens to thousands of times fewer than zeros. Maximum Likelihood estimates of the logit model suffer from finite-sample bias whose degree dependents on the number of cases of the less-frequent outcome.

[3] At an exchange rate of 1 USD = 1,800 Tz Shillings, this is equivalent to $8.12.

farmer's herd increases. Membership in a group implies greater social capital, which may improve the farmer's credit worthiness and access to informal loans from fellow group members. It also implies greater access to information about the available sources of loans and their terms and conditions, and greater access to formal loans from credit schemes that require group membership. In addition, as observed by Barham and Chitemi (2009), improving a group's market performance may require substantial capital and this may in turn compel group members to borrow to meet their financial obligations towards the group, including membership, subscription and other dues.

Household size and total land owned by a household may be considered as measures of the household's initial resource endowment, while education of the household head is an indicator of the borrower's managerial capacity. We expect the coefficients on each of these variables to be positive. Herd size is an indicator of the household's ability to pledge collateral, whereas distance from the household to the nearest trading center captures accessibility to information, business services (including financial services) and infrastructure. Coefficients on the two variables are expected to be positive. Permanent income is a function of current and past income (Iqbal 1983). Thus current income is used as a proxy for permanent income, which indicates the loan repayment capacity of a household, notwithstanding collateral pledged. We expect an increase in income to increase borrowing, but we are also interested in determining the specific source(s) of income that would increase borrowing. Age and sex of household head are believed to influence households' time preference for consumption but their effects have been ambiguous in previous studies.

6. Regression results

Results from the usual logit model and the rare events logit model are presented in table 9, and the level of significance considered in this study is 10%. Both models are statistically significant. It can be seen that in the usual logit model, only two variables are significant; age of the household head and membership in a group significantly increase the probability of borrowing. The rare events logit model gives us bias-corrected coefficients with reduced variance and as such, four coefficients are statistically significant. Similar to the logit model results, age of the household head and membership in a group are significant. In addition, income from the sale of other cattle products and income from cattle services also seem to increase the probability of borrowing. Contrary to our expectation, the use of artificial insemination does not affect the probability of borrowing. A slightly meaningful interpretation of the effect of the significant variables is the odds interpretation obtained by calculating e^{β} for the rare events model as shown in table 10. The odds in favor of borrowing increase by 1.03 (or 3%) for a one-year increase in the age of the household head, and by 5.79 when a household member joins a group. A one-shilling increase in either type of income increases the odds by one.

But even more informative are the absolute probabilities, relative probabilities, and attributable probabilities (first differences) that can be calculated from the rare events logit model. Absolute probability is the probability of borrowing given the level(s) or value(s) of the explanatory variable(s), i.e., $\Pr(CREDIT = 1 | X = x)$, whereas relative probability is the probability of borrowing for given values of *X* relative to the probability of borrowing for some baseline values of *X*. For instance, in the case of a binary explanatory variable *GROUP*, the relative probability $\Pr(CREDIT = 1 | GROUP = 1) / \Pr(CREDIT = 1 | GROUP = 0)$ is the probability of borrowing when a household has a group member, relative to the probability of borrowing

when the household does not have a group member. The first difference measures the effect of an explanatory variable on the probability of borrowing. It is the change in the probability due to a change in the explanatory variable. In the case of *GROUP*, the first difference would be $\Pr(CREDIT = 1 | GROUP = 1) - \Pr(CREDIT = 1 | GROUP = 0)$. The different probabilities are calculated at the 95% confidence interval and are summarized in table 11.

Table 9: Regression results from logit and rare events logit models

	Logit model		**Rare events logit model**	
Variable	**Coefficient**	**p-value**	**Coefficient**	**p-value**
HHSIZE	0.088	0.314	0.092	0.361
	(0.088)		(0.100)	
DISTANCE	0.013	0.396	0.015	0.457
	(0.015)		(0.021)	
EDUCATION	0.075	0.258	0.069	0.237
	(0.066)		(0.058)	
AGE	0.029	0.066	0.028	0.049
	(0.016)		(0.014)	
GENDER	0.706	0.223	0.773	0.151
	(0.579)		(0.539)	
LAND	-0.002	0.705	0.002	0.719
	(0.006)		(0.005)	
HERDSIZE	-0.013	0.104	-0.010	0.122
	(0.008)		(0.006)	
GROUP	1.988	0.000	1.756	0.001
	(0.564)		(0.551)	
AI	0.476	0.284	0.425	0.330
	(0.444)		(0.437)	
FEEDSYS	-0.185	0.702	-0.178	0.704
	(0.483)		(0.469)	
INCOMECAT	2.06E-07	0.338	2.38E-07	0.234
	(2.15E-07)		(2.0E-07)	
INCOMEOTHERCAT	0.0003	0.626	0.0008	0.061
	(0.0006)		(0.0004)	
INCOMECATSERV	-9.12E-06	0.592	0.00001	0.045
	(0.00002)		(7.38E-06)	
INCOMECROP	-3.25E-07	0.734	9.56E-07	0.339
	(9.55E-07)		(1.0E-06)	
INCOMEOTHER	-1.64E-07	0.484	-6.15E-08	0.687
	(2.35E-07)		(1.53E-07)	
CONSTANT	-6.320	0.000	-6.109	0.000
	(1.231)		(1.162)	

Dependent variable is CREDIT. Figures in parentheses are standard errors.

Table 10: Odds of significant variables in the rare events logit model

Variable	e^{β}
AGE	1.03
GROUP	5.79
INCOMEOTHERCAT	1.00
INCOMECATSERV	1.00

Table 11: Absolute, attributable and relative probabilities from the rare events logit model

Variable	Absolute probability	First difference	Change in relative probability (%)
AGE		20 Years to Mean: 0.024 [-0.001 - 0.052] Mean to Max: 0.129 [0.005 - 0.438]	
GROUP	0.052 [0.027 - 0.097]	0 to 1: 0.093 [0.043 - 0.157]	0 to 1: 5.296 [1.951 - 14.839]
INCOMEOTHERCAT		0 to Mean: 0.0009 [-0.00001 - 0.002] Mean to Max: 0.697 [-0.008 - 0.945]	
INCOMECATSERV		0 to Mean: 0.004 [-0.0002 - 0.010] Mean to Max: 0.947 [0.199 - 0.972]	

Figures in brackets are confidence intervals.

The absolute probability is calculated for all four explanatory variables combined, and with the variables set to their mean values. Thus the probability of borrowing for 'an average' cattle keeping household in the study area is 5.2%[4]. Regarding first differences, we find that if a household joins a self-help group, the probability of borrowing increases by 9.3%. The impact of the other variables is quite small; for instance, an increase in the age of the household head by 26 years increases the probability of borrowing by only 2.4%, while the effect of the different income types is negligible. In fact holding other factors constant, for any non-borrowing household that has either type of income falling below the sample mean, a substantial increase in

[4] When all explanatory variables are set to their mean values and included in the calculation, the probability of borrowing is 5.3%.

its probability to borrow can only occur if that income increases to levels beyond the sample mean. The importance of membership in a group is further indicated by the percentage change in the relative probability of borrowing; the probability of borrowing increases by 5.3% for a household joining a group relative to the probability of borrowing by a household that is not a member of a group.

The tobit model regression results of the loan demand equation are shown in table 12. All slope coefficients are jointly significant and they represent the marginal effects of the regressors on the latent variable rather than on the loan amounts borrowed. Several variables were used in both the reduced-form and structural equations, and those presented in table 12 produced the best fit for the structural equation. From the Wald test of the exogeneity of interest rates, we cannot reject the null hypothesis of no endogeneity. That interest rates are exogenous is plausible. Interest rates were liberalized in the early 1990s, and nearly 60% of the indebted households in the sample had acquired their loans from formal sources including private microfinance institutions, whose rates are likely to be similar for all borrowers, unlike those of informal lenders. 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. In addition, the effect of interest rate on demand for credit is statistically insignificant. A similar result has been found by Atieno (1997) for Kenya and Diagne (1999) for Malawi. If interest rates do not matter in the demand for loans, then, ideally, the supply of credit should not be constrained since lenders would be able to set interest rates high enough to generate profits. But it has been argued that in low-income countries, demand for

and supply of credit in rural areas are affected by several others factors more than they are by interest rates (Desai and Mellor 1993).

Table 12: Tobit model regression results

Variable	Coefficient	p-value
INTEREST	380575.70	0.838
	(1861936)	
DISTANCE	19713.54	0.137
	(13254.17)	
EDUCATION	43188.73	0.498
	(63718.36)	
AGE	18844.05	0.264
	(16871.75)	
HERDSIZE	-4521.451	0.436
	(5799.04)	
GROUP	1335299	0.099
	(808598.40)	
AI	824419.20	0.068
	(452023.40)	
FEEDSYS	-187072.30	0.696
	(479056.70)	
CONSTANT	-5485700	0.000
	(1327970)	

Figures in parentheses are standard errors.

The only statistically significant coefficients are those on the two variables of interest, *GROUP* and *AI*, which are positive and significant at the 10% level as expected. A model capturing the interaction between the two variables was estimated but found not to be statistically significant. Therefore the differential effect of membership in a group is constant across AI and non-AI users, and vice-versa. The marginal effect of a given explanatory variable on the observed variable (loan amounts borrowed) can be calculated theoretically by multiplying the estimated coefficient by an adjustment factor. But computationally, 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[5].

7. Summary and conclusion

This study has attempted to provide an understanding of the effect of technology adoption and collective action on the demand for credit among dairy farmers in rural Tanzania. Using cross-sectional data from four districts in Morogoro and Tanga regions, the incidence of borrowing among cattle keepers is 7%, which is comparable to that obtained nationally for livestock keepers. This result suggests that borrowing is a rare occurrence among dairy farmers, and as such, we employ the rare events logit model to estimate the effects of the two variables of interest on the probability to borrow.

We find that membership of a household in a group increases the probability of borrowing but the effect of AI use is not statistically significant. However, both variables significantly increase the amount of funds borrowed, as revealed by the tobit model. Therefore it appears that unlike group membership, AI use does not increase access to credit. But just like group membership, it unequivocally increases the amount of funds borrowed. We conclude that collective action significantly increases both access to credit and amount of funds borrowed, while technology adoption primarily increases the latter. It could be that households that adopt new dairy farming technologies are those that already have access to credit.

Although the study has found collective action to significantly increase the demand for credit, it raises the question as to why the concept of SACCOS, which is in fact characterized by collective action and has been supported by the government in terms of policy, has not

[5] As a case in point, the maximum likelihood estimator produces a marginal effect of 828,120.50 on the latent variable with respect to AI use, but 97,509.41 on the observed variable for households that borrowed and a much smaller value for all households.

considerably increased access to credit among livestock keepers in Tanzania. Our data shows that only 16% of all households are members of SACCOS compared to 77% that belong to livestock producer groups. We have established that interest rates do not constrain demand for credit; therefore to answer this question requires an examination of the additional terms and conditions related to membership in and borrowing from SACCOS in the context of their suitability for livestock keepers.

Members of a rural SACCOS are in most cases members of a primary cooperative society through which they sell their products. The SACCOS operates a group share account with a commercial bank, and it is through this account that members receive payment for their product from the cooperative. Using the SACCOS' savings, an individual may be given a collateral-free loan that is proportional to his/her savings with the SACCOS, and refunds are automatically deducted from the cooperative's payments to the borrower.

The linking of credit with both aggregate and individual savings presents a challenge to the formation of SACCOS based on livestock production. Clearly, the success of a credit scheme that is product-based or sector-dependent is attendant on the extent to which production is market-oriented. According to Covarrubias, Nsiima and Zezza (2012), only 8% of total agricultural output marketed are livestock products, and the share of livestock in total household income is 13%. Given the small share of income, savings from livestock income are bound to be relatively small and unattractive for mobilization towards formation of livestock SACCOS. Nonetheless, collective action among smallholder dairy farmers has the potential to boost demand for credit and therefore as the Tanzanian government supports the formation of dairy farmer groups and cooperative societies, it ought to assess and support other forms of rural finance initiatives such as those based on interlinked credit-product transactions that seek to

adequately lend to this category of farmers. Moreover, the government's continued support for technology adoption certainly makes the need for livestock-tailored credit services an imperative.

References

Abdulai, A and W.E. Huffman. 2005. The Diffusion of New Agricultural Technologies: The Case of Crossbred-Cow Technology in Tanzania. *American Journal of Agricultural Economics* 87(3): 645–659.

Ali, D.A., and K. Deininger. 2012. Causes and Implications of Credit Rationing in Rural Ethiopia: The Importance of Spatial Variation. *Policy Research Working Paper* 6096. Washington DC: World Bank.

Amani, H., L.A. Msambichaka, S. Hedlund and M. Lundahl. 1987. Agricultural Credit in Tanzania: A Peasant Perspective. *Savings and Development* 4(XI): 379–400.

Atieno, R. 1997. Determinants of Credit Demand by Smallholder Farmers in Kenya: An Empirical Analysis. *Journal of Agriculture in the Tropics and Subtropics* 98(1): 63–71.

Barham, J and C. Chitemi. 2009. Collective Action Initiatives to Improve Marketing Performance: Lessons from Farmer Groups in Tanzania. *Food Policy* 34: 53–59.

Bratton, M. 1986. Farmer Organizations and Food Production in Zimbabwe. *World Development* 14(3): 367–384.

Briones, R.M. 2009. Do Small Farmers Borrow Less when the Lending Rate Increases? Interest Rate Elasticity of Rice Farmers in the Philippines. *Asian Economic Journal* 23(4): 439–455.

Clar de Jesus, R.B and C.E. Cuevas. 1988. The Demand for Funds among Agricultural Households in the Philippines. *Working Paper Series No.* 88-21. Makati City: Philippine Institute for Development Studies

Covarrubias, K., L. Nsiima and A. Zezza. 2012. Livestock and Livelihoods in Rural Tanzania: A Descriptive Analysis of the 2009 National Panel Survey. World Bank, FAO, AU-IBAR, ILRI and Tanzania Ministry of Livestock and Fisheries http://documents.worldbank.org/curated/en/2012/06/19356801/livestock-livelihoods-rural-tanzania-descriptive-analysis-2009-national-panel-survey (accessed on November 8, 2014).

David, C.C and R.L. Meyer. 1979. A Review of Empirical Studies of Demand for Agricultural Loans. Columbus: Ohio State University.

De Wolf, J. 1995. Privatization and Livestock Owners Organization in Kagera. In *Strategies for Market Orientation of Small Scale Milk Producers and their Organizations.* (Eds) Kurwijila, L.R, J. Henriksen, A.O.O. Aboud and G.C. Kifaro. Proceedings of a Workshop held at Morogoro Hotel, Morogoro, Tanzania, March 20-24, 1995. FAO and Sokoine University of Agriculture

Dercon, S. 1998. Wealth, Risk and Activity Choice: Cattle in Western Tanzania. *Journal of Development Economics* 55: 1–42.

Desai, B.M and J.W. Mellor. 1993. Institutional Finance for Agricultural Development: An Analytical Survey of Critical Issues. Food Policy Review 1, Washington D.C: International Food Policy Research Institute

Diagne, A. 1999. Determinants of Household Access to and Participation in Formal and Informal Credit Markets in Malawi. FCND Discussion Paper No. 67. Washington D.C: International Food Policy Research Institute

Fatima, A. 2009. Socioeconomic Constraints to Demand for Borrowing among Rural Females of Pakistan. *International Journal of Social Economics* 36(11): 1050–1070.

Fischer, E and M. Qaim. 2012. Linking Smallholders to Markets: Determinants and Impacts of Farmer Collective Action in Kenya. *World Development* 40(6): 1255–1268.
Freeman, H.A., S.K. Ehui and M.A. Jabbar. 1998. Credit Constraints and Smallholder Dairy Production in the East African Highlands: Application of a Switching Regression Model. *Agricultural Economics* 19: 33–44.
Giné, X and D. Yang. 2009. Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi. *Journal of Development Economics* 89: 1–11.
Guirkinger, C. 2008. Understanding the Coexistence of Formal and Informal Credit Markets in Piura, Peru. *World Development* 36(8): 1436–1452.
Jabbar, M.A., S.K. Ehui and R. Von Kaufmann. 2002. Supply and Demand for Livestock Credit in Sub-Saharan Africa: Lessons for Designing New Credit Schemes. *World Development* 30(6): 1029–1042.
Iqbal, F. 1983. The Demands for Funds by Agricultural Households: Evidence from Rural India. *Journal of Development Studies* 20(1): 68–86.
Jia, X., C. Xiang and J. Huang. 2013. Microfinance, Self-Employment, and Entrepreneurs in Less Developed Areas of Rural China. *China Economic Review* 27: 94–103.
Kaliba, A.R.M., A.M. Featherstone and D.W. Norman. 1997. A Stall-Feeding Management for Improved Cattle in Semiarid Central Tanzania: Factors Influencing Adoption. *Agricultural Economics* 17: 133–146.
Khoi, P.D., C. Gan, G.V. Nartea and D.A. Cohen. 2013. Formal and Informal Rural Credit in the Mekong River Delta of Vietnam: Interaction and Accessibility. *Journal of Asian Economics* 26: 1–13.
Kimuyu, P.K. 1999. Rotating Savings and Credit Associations in Rural East Africa. *World Development* 27(7): 1299–1308.
King, G and L. Zeng. 2001a. Explaining Rare Events in International Relations. *International Organization* 55(3): 693–715.
King, G and L. Zeng. 2001b. Logistic Regression in Rare Events Data. *Political Analysis* 9(2): 137–163.
Kurwijila, L.R. 1995. Milk Marketing and Processing Options for Smallholder Dairy Cooperative Organizations: The Case of Serengeti and Mwakaleli Dairy Cooperatives in Tanzania. In *Strategies for Market Orientation of Small Scale Milk Producers and their Organizations.* (Eds) Kurwijila, L.R, J. Henriksen, A.O.O. Aboud and G.C. Kifaro. Proceedings of a Workshop held at Morogoro Hotel, Morogoro, Tanzania, March 20-24, 1995. FAO and Sokoine University of Agriculture
Land O'Lakes, Inc. 2007. Tanzania Dairy Enterprise Initiative. Final Report http://pdf.usaid.gov/pdf_docs/PDACI870.pdf (accessed January 20, 2015)
Li, L. 2008. Three Essays on China's Economic Reform. PhD dissertation, University of Maryland
Maro, P.S. 1990. The Impact of Decentralization on Spatial Equity and Rural Development in Tanzania. *World Development* 18(5): 673–693.
Ministry of Livestock and Fisheries Development. 2011. Livestock Sector Development Programme. Dar es Salaam: United Republic of Tanzania
Mohamed, K. 2003. Access to Formal and Quasi-Formal Credit by Smallholder Farmers and Artisanal Fishermen: A Case of Zanzibar. Research Report No. 03.6. Zanzibar: Ministry of Agriculture, Natural Resources, Environment and Cooperation
Mpuga, P. 2008. Constraints in Access to and Demand for Rural Credit: Evidence from Uganda. Paper Presented at the African Economic Conference, November 12-14, 2008, Tunis

Njehu, A and A. Omore. 2014. Milk Production, Utilization and Marketing Channels in Tanga and Morogoro Regions of Tanzania. Brief 8. Nairobi: International Livestock Research Institute

Okten,C and U.O. Osili. 2004. Social Networks and Credit Access in Indonesia. *World Development* 32(7): 1225–1246.

Pal, D and A.K. Laha. 2015. Sectoral Credit Choice in Rural India. *Journal of Choice Modelling* 14: 1–16.

Rahji, M.A.Y and O.I.Y. Ajani. 2007. Demand for Loans under the Small and Medium Enterprises Equity Investment Scheme (SMEEIS) in Nigeria. *Journal of Food, Agriculture and Environment* 5(1): 378–381.

Rushalaza, V.G and J.S. Kasonta. 1992. Dual-Purpose Cattle in Central Tanzania. In *Future of Livestock Industries in East and Southern Africa.* (Eds) Kategile, J.A and S. Mubi. Addis Ababa: International Livestock Centre for Africa

Rweyemamu, D.C., M.P. Kimaro and O.M. Urassa. 2003. Assessing Micro-Finance Services in Agricultural Sector Development. A Case Study of Semi-formal Financial Institutions in Tanzania. *Economic and Social Research Foundation* 1–46.

Salami, A., A.B. Kamara and Z. Brixiova. 2010. Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities, Working Papers Series N° 105. Tunis: African Development Bank

Shoji, M., K. Aoyagi, R. Kasahara, Y. Sawada and M. Ueyama. 2012. Social Capital Formation and Credit Access: Evidence from Sri Lanka. *World Development* 40(12): 2522–2536.

Stiglitz, J.E and A. Weiss. 1981. Credit Rationing in Markets with Imperfect Information. *American Economic Review* 71(3): 393–410.

Swain, R.B. 2007. The Demand and Supply of Credit for Households. *Applied Economics* 39(21): 2681–2692.

Swaminathan, H., R.S. Du Bois and J.L. Findeis. 2010. Impact of Access to Credit on Labor Allocation Patterns in Malawi. *World Development* 38(4): 555–566.

Trigeorgis, L. 1996. *Real Options: Managerial Flexibility and Strategy in Resource Allocation.* Cambridge, MA: MIT Press

United Republic of Tanzania. 2001. Rural Development Strategy. Main Report. Dar es Salaam: Prime Minister's Office

United Republic of Tanzania. 2005. The Cooperative Reform and Modernization Program 2005 – 2015. Dodoma: Cooperative Development Department

Wangwe, S and M. Lwakatare. 2004. Innovation in Rural Finance in Tanzania. Paper Presented at the Third Annual Conference on Microfinace, Arusha, March 15-17, 2004.

Yuan, Y and L. Xu. 2015. Are Poor Able to Access the Informal Credit Market? Evidence from Rural Households in China. *China Economic Review* 33: 232–246.

Zylstra, L., C. Lyimo and I. Rutamu. 1995. Milk Production and Marketing in Tanga Region: Efficiency of Farmer Cooperatives versus Private Sector. In *Strategies for Market Orientation of Small Scale Milk Producers and their Organizations.* (Eds) Kurwijila, L.R, J. Henriksen, A.O.O. Aboud and G.C. Kifaro. Proceedings of a Workshop held at Morogoro Hotel, Morogoro, Tanzania, March 20-24, 1995. FAO and Sokoine University of Agriculture