THE IMPACT OF AGRICULTURAL CREDIT ON DEMAND FOR FACTORS OF PRODUCTION, FARM OUTPUT, AND PROFITABILITY IN KENYA

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Agricultural, Food, and Resource Economics – Doctor of Philosophy

2015

ABSTRACT

THE IMPACT OF AGRICULTURAL CREDIT ON DEMAND FOR FACTORS OF PRODUCTION, FARM OUTPUT, AND PROFITABILITY IN KENYA

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This dissertation develops a model that allows not only estimating the impacts of agricultural loans on farm outcomes, but also explaining the pathways through which access to credit affects the outcomes. This approach provides a fuller understanding of the extent to which innovations in rural financial markets could improve farm production and profitability. The study takes advantage of an exogenous shock in agricultural credit in Kenya to evaluate the impact of a group credit program on farm outcomes. The results show that: (i) group credit increased demand for nitrogen nutrients in fertilizers by 43.65 percent, (ii) there was no impact on demand for phosphorous and potassium nutrients, and (iii) there was no impact on demand for hybrid seeds.

There is also growing interest to understand the relationship between credit constraints and human capital acquisition. The results show that group credit increased demand for adult hired labor by 141.82 percent and decreased demand for child labor by 51.82 percent. That credit frees child time from farm labor suggests that innovations in financial markets could have long-term effects on human capital development, and therefore should not be evaluated only on the basis of short-term outcomes. The result that group credit increased demand for adult hired labor suggests rural labor markets can be effective in raising incomes for land constrained but labor abundant rural households – while keeping children away from working in farms.

The study also estimates the impact of group loans on maize profitability. The results lead to the conclusion that group credit is profitable when used to purchase fertilizers and hire

labor for maize production. An average farmer invested KES 4814.75 from group loans to maize production and realized profits of KES 3171.72, which translates to a 65.87 percent return on investment. The average loan size was Kenya Shillings (KES) 15,760.98 but only KES 4814.75 (about 30.55 percent) was used to purchase primary inputs in maize production (fertilizers and hired labor). The remaining 69 percent may have been used for consumption needs, short-term investments in competing enterprises (e.g. dairy), and long-term investments such as education.

Results from stochastic frontier production function indicates that group credit improves allocative efficiency but has no effect on technical efficiency. The conclusion that group credit improves allocative efficiency draws from estimates of marginal revenue products and estimates of impact of group credit on factor demands. We found that group credit had a positive and significant effect on demand for nitrogen and hired adult labor. Both inputs had positive marginal revenue products, relative to factor prices, indicating that farmers who received group loans improved their allocative efficiency by using more of these inputs. However, phosphorous and potassium have the largest marginal revenue products relative to factor prices, but access to group credit did not increase demand for these nutrients. We conclude that borrowing farmers could have improved their allocative efficiency even further with increased demand for phosphorous and potassium.

This dissertation is dedicated to my father, the late Mzee Zakayo Mghenyi.

ACKNOWLEDGEMENTS

This work has benefitted from the efforts of many people and organizations. I am almost certain I will not be able to name everybody. Many thanks to you all! Special thanks goes to all the professors who taught me at Michigan State University. I am particularly grateful for the leadership and support of Dr. Scott M. Swinton, Associate Chairperson of the Department of Agricultural, Food, and Resource Economics. I would also like to thank my dissertation committee: Dr. Robert Myers, Dr. Thomas Jayne, Dr. Jeffrey Wooldridge, and Dr. John Giles for the many years of guidance. My study partners Hikuepi Katjiuogua, Julius Kirimi, Honglin Wang, Vandana Yadav, Makoto Tanaka, and Shauffique Siddique created a conducive environment for collaborative learning at various stages of my Ph.D. program. I will forever remain grateful.

My dissertation research was generously supported through a fellowship from the Norman E. Borlaug Leadership Enhancement in Agriculture Program (Borlaug LEAP). I will forever remain indebted to the Borlaug LEAP. The Program allowed for a mentor in Dr. Hugo De Groote at CIMMYT in Nairobi Kenya, who went beyond the call of duty to support the data collection. I am very thankful to enumerators and all farmers who responded to the interviews. Last but not least, I would like to sincerely thank officials of the Cereal Growers Association of Kenya (CGAP), the Kenya Maize Development Program (KMDP), and the Kesses Division Farmers Marketing Federation (KDFMF) for allowing this research to happen.

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CHAPTER ONE: INTRODUCTION

1.1. Background

Economic development and wealth distribution depends on the set of institutions that develop over time to govern capital accumulation (Banerjee and Newman, 1993). Joint liability credit contracts ("group loans") is an example of an institution with potential to solve some of the underlying sources of credit constraints. The joint liability feature in group loan schemes allows borrowers to obtain loans without having to provide conventional collateral (Besley and Coate, 1995). Joint liability requires borrowers to monitor one another (peer monitoring) and this reduces moral hazard (Stiglitz, 1990; Varian, 1990; de Aghion, 1999). The advantage of peer monitoring is that unlike Banks, group members would have access to detailed local information about economic activities of fellow borrowers as well as their personal characteristics. Under joint liability credit contracts, local information is used to evaluate loan applications and repayment ability thus mitigating adverse selection (Ghatak and Guinnane, 1999; de Aghion and Gollier, 2000; Ghatak, 1999; Van Tassel, 1999).

By addressing adverse selection, moral hazard, and the need for conventional collateral, group loans have potential to relax credit constraints and provide working capital that allows technology adoption and capital accumulation by farmers that may have been excluded from conventional loans. This is important for development because the effects of credit constraints on technology adoption and occupation choices could lead to long-term consequences for the levels of per-capita incomes in the economy and the distribution of income (Aghion and Bolton, 1997; Ghatak and Jiang, 2002).

This study evaluates the impact of a joint liability credit program on agricultural outcomes. The study takes advantage of an exogenous shift on the supply of funds and constructs a quasi-experiment to evaluate demand-side behavior of maize farmers in Kenya. In particular, the study employs a profit-maximization conceptual framework to: (i) evaluate the impact of group loans on demand for inputs in maize production, (ii) estimate marginal products of the inputs, and (iii) examine the impact of group loans on maize productivity, production, and profits.

At least three types of credit constraints occur in rural credit markets; (i) “price rationing”, (ii) “quantity rationing”, and (iii) “risk rationing”. Price rationing occurs when loans are not profitable because the cost of credit is higher than expected returns. Price rationing is often characterized as high interest rates. Governments have used various measures to supply credit to farmers who cannot borrow due to high interest rates, for example laws that require mandatory lending of a certain proportion of commercial bank loans to agriculture or establishing state-run agricultural banks that lend to farmers at subsidized interest rates.

Quantity rationing refers to a situation where loans are profitable but borrowers cannot get desired loan amounts at the equilibrium rate of interest. The suppliers of credit would not raise interest rates above the equilibrium rate because that would attract risky borrowers and reduce expected profits for them (Stiglitz and Weiss, 1981). In most uses the term credit rationing refers to quantity rationing. This type of rationing is due to lenders having imperfect information about borrowers, which leads to adverse selection and moral hazard (Stiglitz and Weiss, 1981; Ghosh, Mookherjee et al., 1999; Banerjee and Duflo, 2004; Bell, Srinivasan, and Udry, 1997; and Kochar, 1997).

Risk rationing occurs when borrowers decline credit because it entails too much risk. Credit may be profitable at given interest rate-collateral combination, but risk-averse borrowers choose not to borrow – for example to avoid the risk of losing land required as collateral. These type of credit constraints have been discussed in Binswager and Sillers (1983); Boucher (2000); Boucher, Carter, and Guirkinger (2008). Farmers who exit credit markets because of risk considerations will often retreat to low-investment, low-risk, and often low-return production technologies, for example traditional farming methods that entail relatively lower working capital outlays.

Group lending has potential to reverse both quantity rationing and risk rationing but not price rationing[1]. In addition to mitigating both moral hazard and adverse selection, the joint liability feature of group credit involves peer monitoring that provides a "social collateral" which may replace the need for conventional collateral (Besley and Coate, 1995). Joint liability credit contracts may become attractive to risk-rationed individuals that had voluntarily exited credit markets because of the risk of losing collateral. Furthermore, group members participating in joint liability contracts are often involved in activities designed to improve linkages with input and output markets. For example most groups in the study area were involved in input buying arrangements that took advantage of economies of scale in transport and bargaining to provide relatively lower prices, as well as output marketing arrangements to reach larger buyers, often at lower cost of marketing (due to economies of scale) and better output prices.

[1] A recent review of micro-lending schemes throughout the world suggests that they charge interest rates that are at least as high as commercial bank rates (CGAP, 2009). This does not mean they are exploitative because administrative costs in micro-lending are relatively higher.

1.2. The Joint Liability Credit Program Being Evaluated

The joint liability credit program we evaluate was financed by the Agricultural Finance Corporation of Kenya (AFC) – a government owned bank with a specific mandate to finance investments in the agriculture sector. While the AFC has a mandate to lend to all types of farmers, most of its loans go to large and medium-scale farmers because small farmers cannot afford the required collateral or lack helpful political connections. The credit program was an attempt to address the disparity. It started with the backing of the Cereal Growers Association of Kenya (CGAP) and the Kenya Maize Development Program (KMDP). The program was available to farmers that belonged to farming groups affiliated to Kesses Division Farmers Marketing Federation (KDFMF), subject to meeting some eligibility criteria. The KDFMF is an apex organization of farmer groups in Kesses division, Uasin Gishu district. Kesses division is a high potential agriculture zone where maize production is among the most important sources of farm income. A large part of Kesses division is historically a settlement scheme. Most of the sampled households moved there several decades ago after the country gained independence in 1963.

The group credit program started in the 2006 crop production season. A year later it had expanded more than two-fold to include at least 102 farmer groups, which received loans in excess of US$ 600,000 to share among approximately 3,000 farmers. All loans are in cash and payment is due at the end of a production season (effective loan duration is about 12 months). The interest rate charged by AFC is 10 percent per year. The funds flow from AFC to the federation, then to groups, and finally to the farmer. Some groups would charge additional interest to build the groups own capital. According to estimates from the International Monetary Fund (IMF), the commercial interest rate in Kenya averaged about 13.5 percent per year in 2006 and 2007 – which is lower than interest charged by AFC. However, the sample of farmers interviewed claim other borrowing costs add to the 10 percent interest and contend that interest rate on group loans exceeds the commercial rate when all costs are factored. It is hard to verify these claims because commercial loans also involve other borrowing costs in addition to interest. A recent review of micro-lending schemes suggests that group credit programs charge interest rates at least as high as commercial bank rates (CGAP, 2009). Other borrowing costs involved in the AFC program include an application fee of KES 2,500 for loans up KES 50,000, commitment fee of 1.5 percent of the loan, and some legal fees.

The AFC group credit program aims to help farmers bridge their working capital needs in purchasing inputs for maize production[2]. The objective appeared to be very well understood by borrowing members as all sampled farmers were completely aware the loans were supposed to be used only for maize production. Loans were released before planting maize. As with most programs that offer group loans, AFC requires borrowing members to sign a joint liability clause, which means they are responsible for repayment of not just their own loans, but also loans of all members within their group.

1.3. Description of the Multi-stage Lending Process

The first stage in the group lending process begins with the federation (KDFMF) notifying a group about its eligibility to participate in the program. The main determinant of group eligibility is the number of years it had affiliation with the KDFMF. A group attains eligibility to the program after two consecutive years of successful affiliation with KDFMF. The federation freely admits groups that are registered with the relevant government department. And the requirements for registration by government are written minutes showing a group has been

[2] Maize is an important source of farm incomes in the study region

formed with at least three officials (chairperson, treasurer, secretary) and a bank account in the name of the group. In the study area most adults belong to at least one group of some kind, and group membership is firmly part of associational life.

Agriculture is the most important activity in the area and so most groups tend to be related to farming activities. Even women groups that are involved in rotating savings and credit activities tend to contribute towards working capital for farming activities and household needs. The KDFMF has powers to declare a group ineligible to participate in the credit program even after completing two years of successful affiliation with the federation. In 2007, after one borrowing cycle, some groups were already declared ineligible due to default on payments and high turnover in membership. The KDFMF explained that stability of membership in a group is quite important because joint liability works when there is effective peer monitoring among members to mitigate moral hazard. And peer monitoring is more effective in groups that have cultivated social capital. It is believed that membership turnover is detrimental to building social capital.

The second stage involves members of eligible groups submitting loan applications to their groups (not to the federation). Loan applications are assessed by a committee of about three officials in the group, who decide whether to approve the request as is or to recommend some adjustment as a pre-condition for approval. Loan applications are usually adjusted, rather than denied, apparently because capturing loans is a key goal for most groups. We learned through focus group discussions that the main reasons loan committees would recommend revised applications were if borrowers requested more loan amounts relative to size of land prepared for maize cultivation, or more loan amounts relative to value of liquid assets offered as security to the group[3]. The most common assets offered include livestock, furniture, and electronics equipment. Not all members in eligible groups apply for loans. Only loan applicants are required to offer assets as security to the group, which effectively rules out non-borrowing members from joint liability. There are various reasons why some members may not apply for loans. For example, members without working capital constraints would not need group loans and may self-select out of the program. Members with poor credit record or outstanding loans (from other sources) may also self-select out of the program. The second stage ends when the evaluation committee within the group approves loans and effectively imposes a credit limit for each applicant.

The third stage involves the group presenting the list of loan applications to the federation, including information such as names of farmers requesting loans, loan amounts approved for each applicant, area of land to be cultivated for maize production by each applicant, and value of liquid assets provided as security to the group. The federation examines the records to ensure the groups followed established guidelines in evaluating loan applications, including enforcing a ceiling on loan size based on acres of land cultivated. The ceiling is determined based on notional working capital requirements to purchase inputs for maize cultivation.

The fourth stage involves the federation recommending the aggregate loan requests from all groups to the lender (AFC). The recommendation comes with a legally binding statement from the federation that the federation has mechanisms to enforce full repayment. The lender also requires the federation to provide a great deal of information about borrowing groups, in addition to serving as guarantor for the aggregate loan. The information required include list of members benefiting, loan amounts approved for each (credit limits), an agreeable supervision

[3] Notice that borrowers offer security to the group, not to AFC, and only the group and federation could claim these assets in case of defaults

plan, whether the group has a management unit, powers bestowed on the management unit, membership size, minutes of recent group meetings, membership turnover, length of time the group has been operational, a certificate of registration with the department of social services, the groups constitution etc. The lender would use this information to decide whether to supply the aggregate credit to the groups.

The fifth stage involves the lenders deciding to supply loans to groups. It marks the assignment of loans (treatment) to borrowers in eligible groups. We learned from discussions with AFC that the decision relies on information about prospective borrowing groups and the legally binding indemnification provided by the federation. However, there is evidence the lenders decision to supply loans to the groups relies only on the aggregate loans being fully underwritten by the federation and not group level information. For example, the lender recommends that groups should only approve farmers cultivating more than 5 acres of land. However, groups rarely follow this guideline, and instead most of them put a much lower restriction of half an acre. The federation had previously underwritten loans to groups violating the lenders own guidelines and yet those groups received loans. It would appear the lender did not enforce this particular guideline, perhaps because the default risk is covered by the group through joint liability and by the federation through its role as underwriter of aggregate loans. The AFC hardly assumes any risk as there is no limited liability clause in the contract between the lender and the federation. Although no attention goes to lenders guidelines regarding size of land under maize cultivation, the lender normally enforces the per-acre ceiling on loans, perhaps to discourage borrowers from using loans under the program for anything other than maize cultivation. On its part the federation ensures groups approve only amounts below the per-acre ceiling.

1.4. Sampling

The study relies on household survey data collected between June and August 2007 – roughly in the middle of the 2007 cropping season. The first point of contact for the survey was the offices of the federation. All farmers borrowing through the program were members of farming groups affiliated to the federation. The federation keeps records on various aspects of affiliate groups, including membership, participation in the credit program, list of borrowing farmers, their loan amounts, progress on repayment for individual farmers and at group level, and other services offered to members such as marketing grains to organized large buyers. The federation management assisted the survey team in gathering information about participation in the program.

The survey proceeded as follows. As a first step, we obtained a list of all groups affiliated to the federation, the names of members in each group, the villages where members lived, and the amount of loans obtained by members in 2006 and 2007. Using the data we were able to list 36 villages where at least one member of a group that was eligible in 2006 or 2007 lived and farmed. Next we visited the 36 villages and requested a list of all households from village leaders. We were able to compile a list of identifiable households living and farming in all 36 villages. This list comprised the sampling frame from which a sample for the study was drawn.

A careful examination of the sampling frame revealed that many groups had farmers from different villages. Furthermore, discussions with group officials confirmed that even where a group is eligible to participate in the program, some farmers within the group might not be eligible because of reasons such as previous defaults and lack of assets to offer as security to the group. Groups would evaluate eligibility of a farmer and impose a credit limit only if a farmer applied for a group loan, which means farmers expecting their groups to impose extremely low credit limits could have self-selected out of the program[4]. Such credit constrained but un-creditworthy farmers are not identifiable because non-borrowers also include unconstrained farmers who did not apply because they did need the loans. Therefore there was no data available to categorize farmers as credit constrained or non-constrained. Furthermore, the theoretical notion of credit constrained versus non-constrained is not necessary to evaluate the average treatment effect of the credit program. The borrowing rules are such that the treatment (loan) is received by borrowing farmers in a group and not the group itself. This means the treatment effect will be evaluated at the farmer level because the unit of treatment is a farmer in a group and not the group. The role of the group is in loan appraisal, peer monitoring, and enforcing repayment when loans become due.

The combined list was used to generate four strata of households for the purpose of sampling; (a) households in groups that were ineligible in both years – control households, (b) households that received credit only in 2007 – treatment households, (c) households that received credit in both years, and (d) households in groups that received credit only in 2006 but not in 2007. One more category of households not captured in the above four categories is those that are not members of the federation. The survey did not include such households.

A stratified random sampling approach was applied using weights[5] to ensure each stratum is proportional to its size in the population. The sampling procedure was used to select 360 households – of which 129 were members of groups ineligible in both years (control), 97 received credit in 2007 only (treatment), another 97 were in groups that received credit in both 2006 and 2007, and 37 were in groups that received credit in 2006 but defaulted and were

[4] We had already learned this from the federation
[5] Weights were generated from the combined list

declared[6] ineligible in 2007. The sample size was constrained by the budget of $27,500 for the study. Funding was obtained through the Norman Borlaug Leadership in Agriculture Fellowship Program ($20,000) and Michigan State University's Glenn and Sandy Johnson Fellowship ($7,500)[7].

A survey was conducted using household questionnaires and focus group discussions. The group discussion provided information on important aspects of the group borrowing process, such as how an individual farmer's loan requests are evaluated by their groups, how groups determined credit limits for members, and peer monitoring among borrowing farmers within same group. Although there were some differences in evaluating loan applications, the overall process was quite similar across groups as described in section 1.3 above. The household questionnaire had two parts – the first part collected data on the 2006 production season (recall data) and the second part collected data on the 2007 (current) production season. The quasi-panel data from consecutive years facilitates estimation methods that are robust to unobservable heterogeneity among farmers. The data is comprised of variables such as demand for inputs (fertilizers, seeds, land, and labor), farm assets, demographics, borrowing from group and non-group sources, uses of credit, repayment practices, infrastructure variables etc. The survey also captured data on maize production in the 2006 season, but not in the 2007 season because the crop was still in the field. Similarly, our data includes complete labor use in the 2006 season, but labor use in the 2007 season only captures activities such as land preparation, planting, first weeding etc. and excludes labor use in second weeding and harvesting operations.

[6] Before approving group loans for 2007 the federation conducted an audit on repayment for 2006 loans and declared defaulting groups ineligible

[7] I would like to thank the Norman Borlaug Leadership in Agriculture Fellowship Program, which awarded this study $20,000 and Michigan State University, which awarded $7,500 through the Glenn and Sandy Johnson Fellowship

1.5. Data

1.5.1. Relationship between Credit Limit, Loan amounts, and Collateral

Summary statistics on group loan amounts, credit limit on group loans, and non-group loans are presented in table A1.1. On average, credit limits for group loans are consistently higher than actual group loans in all borrowing categories. There are two reasons explaining the differences. First, groups determine credit limits for borrowers before the federation guarantees the total volume of loan requests, and the federation's decision could involve adjusting loan requests downwards for members, but certainly not upwards. Second, actual loan amounts depend on the supply of funds available to the lender. If the total volume of loan requests exceeds the supply of funds, the lender would inform the federation that it would supply less than amounts requested. In summary, the decisions of the federation and lender could result in farmers receiving loans lower than approved credit limits. On the other hand, there is nothing in the borrowing process to suggest the federation and lender could approve loans higher than credit limits.

A means comparison of group loans and non-group loans suggest that group loans may have crowded out the capacity of households to engage in other borrowing. Non-group loan amounts are only stable in stratum (a) households that were ineligible in both years. In stratum (b) households that were ineligible in 2006 but eligible in 2007, the average size of non-group loans in 2007 fell by about 40 percent from 2006 levels, suggesting group loans may have crowded out other borrowing. In stratum (c) households that borrowed from both group and non-group sources in both years, we find that group loans increased by 19 percent in 2007 while non-group loans decreased by 26 percent, which suggests a substitution effect. The opposite effect happened in stratum (d) households that obtained group loans in 2006 but defaulted and were declared ineligible in 2007 in that the average size of non-group loans increased by about 50 percent in 2007 when they could not participate in the group program. That group borrowing may have crowded out other borrowing suggests that households do have a notional overall credit ceiling for all types of borrowing such that taking out agricultural loans reduces their capacity to borrow for other purposes.

The data suggests that repeated participation in the group program vastly improves information about farmer's creditworthiness. In stratum (c) households that took group loans in both years, the average credit limit in 2007 was 55 percent higher than in 2006, which indicates that successful repayment of 2006 loans improved farmer's creditworthiness, at least in the eyes of their groups. Furthermore, the 55 percent improvement in creditworthiness led to loan amounts increasing by 26 percent in 2007. This indicates that the creditworthiness of farmers increased not only in the eyes of their groups, but also in the eyes of the federation and lender. The dynamics of improved credit limits and loan amounts demonstrate that repeated borrowing reveals information about creditworthiness and has potential to solve information failures that impede proper functioning of rural credit markets. In the same vein, defaulting borrowers revealed negative information about their creditworthiness. In stratum (d) defaulting is associated with a 92 percent decrease in the credit limit and an adverse assessment by the lender who declared them ineligible.

There is asymmetrical response of a lender to revealed creditworthiness of farmers. Although the credit limits of stratum (c) households that had repaid successfully in 2006 increased by 55 percent, the corresponding increase in loans amounts was only 26 percent, implying the lender might have discounted their revealed creditworthiness. On the other hand, stratum (d) households that defaulted in 2006 had their credit limits decrease by 92 percent and this led the lender to declare them ineligible.

Group loans differ from non-group loans in important ways. Only a formal banking institution – AFC – was involved in the group program. But in non-group loans both banking and non-banking lenders were involved to the extent that friends, relatives, and neighbors supplied about 67 percent of non-group loans. Commercial banks and savings cooperatives supplied about 18 percent of non-group loans and non-governmental organization and micro-finance banks supplied nearly 5 percent. Although non-group loans are for varying purposes, about 50 percent are for agriculture enterprises, 25 percent for school fees, 10 percent for business activities and another 10 percent for household needs and medical expenses. About 50 percent of the non-group loans are due within 6 months. In contrast, the group loan program is seasonal credit and loans are due at the end of production season (roughly after 12 months). The average interest rate on non-group loans is about 4 percent annually, but it varies widely from 0 percent to 25 percent. Group loans attract a base interest rate of 10 percent. However, most borrowers indicated that various borrowing fees charged by the lender, federation, and sometimes groups may add up the interest rate significantly.

On average collateral on group loans is at least 5 times higher than credit limits. Borrowing rules do not require collateral several times the amount requested so it is puzzling to find that loans are significantly over-collateralized. A Plausible hypothesis is that there might be an intra-group game where if a borrower places more than required collateral it puts pressure on others to do the same such that in the equilibrium what had started as joint liability collapses to individual liability when default occurs. The collateral required in the group credit program is in the form of liquid assets such as livestock, electronics, and household furniture. These items are quite commonly found in most rural households, at least compared to conventional collateral such as land title. Borrowers may have no problem committing such assets if they believe it improves creditworthiness.

1.5.2. Group Characteristics

Group dynamics suggest there is significant turnover in membership. This may partly explain why groups would demand collateral from borrowing members instead of relying on the "social collateral" suggested in (Besley and Coate, 1995). Group dynamics are captured by proportional turnover (defined as sum of exit and entry divided by group size) and annual turnover (defined as sum of exit and entry annually). Table A1.2 indicates that proportional turnover is lowest for groups that were ineligible in both years (.59) and highest for groups that were eligible in both years (.76). This is puzzling because membership turnover is considered unfavorably by the federation as it is thought to be detrimental to social cohesion and effective peer monitoring. The sum of members exiting and leaving across all groups is at least half the group size at registration. The mean annual turnover tracks the proportional turnover. Groups that defaulted in 2006 lose and replace about three members per year compared to six members per year for groups that repaid successfully in 2006 (the highest annual turnover among the four borrowing categories).

The average size of a group at the time of registering with government authorities was 20 members and there are no differences across borrowing categories. All groups require members to pay entry fees. On average, the fees are highest in groups that were ineligible in both years and lowest in groups that defaulted in 2006, but again the differences are not large considering the fee is a one-time payment. The one-time membership fee is on average less than 20 percent of group loan size.

1.5.3. Agricultural Prices

The reported data on agricultural prices is at the household level. However, we also collected prices from input retailers in market centers where farmers reported they purchased inputs. In cases where farmers were unable to recall the price they received, we used data from the market center where they purchased inputs. Table A1.3 presents means of agricultural prices for maize grains, fertilizers, land preparation, hybrid seed, and agricultural wage labor rate. Maize grain price is reported from the time of planting to reflect the price observed by farmers when making the decision to invest in maize cultivation. There are no significant differences in maize grain prices across the years and among the borrowing categories. Similarly, the price for fertilizers, seeds, and land preparation appear to be stable not only across the strata, but also across the years. The wage rate is higher in 2007 compared to 2006 but there are no differences across borrowing status.

1.5.4. Household Characteristics

Land holding in the study area is about 5.5 acres per household and there are no major differences across borrowing categories (see table A1.4). The highest land holding is among households that were ineligible in both years and the lowest is in those who borrowed and defaulted in 2006 – hardly a difference of one acre. The study area is historically a resettlement scheme and the majority of farmers moved into the scheme about 4 decades ago. The small differences in landholding suggest that land transfers have not occurred at a scale large enough to change the nearly uniform distribution of land allocations associated with resettlement schemes. That ineligible household's reported highest landholding suggests land may not be a factor in accessing group loans.

Most households are male headed and access to group loans is negatively correlated with incidence of female-headed households. On average, the proportion of female-headed households is just over 10 percent, but varies substantially from 6% among those who received credit in both years to 16 percent among those ineligible in both years. That ineligible households are more female-headed suggests these households face some limitations in joining groups that are more likely to secure loans (and possibly other services such as marketing grains and purchasing farm inputs). There are no important differences in household size across borrowing categories. The average age of a household head is about 45 years and that hardly varies across borrowing categories. Households that are ineligible reported highest average age of head (47 years) and the lowest is reported among those who became eligible in 2007 (44 years).

Access to group loans appears positively correlated to ownership of farm assets. Households that were ineligible in both years have lowest value of farm assets and households that are eligible in both years have highest value of farm assets. The value of farm assets in 2007 is nearly twice as high in households that were eligible in both years compared to those ineligible in both years. Furthermore, value of farm assets not only seems correlated with eligibility for group loans but also success for those already participating. Households that participated successfully in 2006 have higher value of farm assets than households that defaulted in the same year. The asset gap is lowest between those ineligible in both years and those who became eligible in 2007 and this indicates the households are quite similar.

The survey collected data on the following infrastructure variables; distances to fertilizer seller, maize market and “motorable” road. The distance to fertilizer seller decreased by about 2 kilometers between 2006 and 2007 in households that became eligible in 2007. In households ineligible in both years the distances decreased by just over 1 kilometer, while in households that borrowed in both years the distance increased marginally by less than a kilometer. This is the only category reporting increased distance to fertilizer seller and it is not clear why. Defaulting households report the highest decline in distance to fertilizer seller – in the order of more than 2 kilometers. Distance to maize market is quite stable across the years, but differs across borrowing groups. Ineligible households are closest to maize sellers, followed by households that borrowed in both years, and the distance is highest among defaulters.

1.5.5. Demand for Agricultural Inputs

Table A1.5 presents summary statistics on demand for the main inputs in maize cultivation – fertilizers, hybrid seed, land, and labor. There are substantial changes in fertilizer application rate (kilogram per acre) in stratum (a) households that were ineligible in both years and also in stratum (b) households that became eligible in 2007. Importantly, fertilizer application rates are similar across the two categories in 2006 when both did not receive group loans. The rate was about 92 kilograms per acre. However, in 2007 ineligible households – stratum (a) – decreased fertilizer use by about 5 kilograms per acre on maize fields, but increased fertilizer use in non-maize fields by about 2 kilograms per acre. On the other hand, households that became eligible in 2007 – stratum (b) – increased fertilizer use by more than 10 kilograms per acre in maize fields, and reduced fertilizer use in non-maize field by about 2 kilograms per acre. The increase of 10 kilograms per acre is not necessarily the impact of group loans as factors other than working capital that may be involved in determining demand for fertilizers e.g. change in input prices. The fertilizer application rate is highest among households that received group loans in both years. Among this category, the fertilizer rate on maize fields did not change between 2006 and 2007 and was about 110 kilograms per acre. Similarly, the fertilizer rate was stable on maize fields among households that defaulted in 2006 and were ineligible in 2007 – about 82 kilograms per acre. However, defaulting households decreased fertilizer use in non-maize fields by about 15 kilograms per acre. When fertilizers were converted to nitrogen equivalents we find that nitrogen application rates track fertilizer application rates quite well across borrowing categories and years.

The area under maize was lowest in ineligible households (about 2.3 acres) and highest in households that borrowed in both years (about 3.3 acres). Households that became eligible in 2007 and defaulting households reported similar patterns of land allocation to maize cultivation – about 2.5 acres. Overall, the differences in area under maize are small across borrowing categories and years. Similarly, labor use in maize cultivation appears quite stable. The hybrid seed rate is quite stable as well, at about 10 kilograms per acre, which is the recommended rate in the study area. Most importantly, nearly all households use hybrid seed varieties and there were no reported cases of switching into and out of hybrid seeds. The study area and the rest of Uasin Gishu district is a high potential maize zone and most farmers have a long history of using hybrid seeds and fertilizers.

Maize yields in 2006 are highest among ineligible households that did not take group loans and lowest among defaulters who took group loans. Ineligible households harvested about 21% more grain per acre. There are no yield differences between households that became eligible in 2007 and those borrowing in both years.

1.6. Conclusions

Group borrowing has potential to solve some of the information failures that impede proper functioning of rural credit markets. We find that repeated participation in group borrowing vastly improves information about farmer’s creditworthiness, not only in the eyes of their groups, but also in the eyes of the federation and lender. Farmers that successfully repaid loans were assessed better credit limits by their group and federation, which in turn led to them receiving higher amounts of loans from the lender compared to the previous year. On the other hand, defaulters were assessed remarkably lower credit limits in the next season and received no loans from the lender.

Furthermore, we find that there is asymmetric response of a lender to revealed creditworthiness of farmers. The credit limits of farmers that repaid successfully in the first year increased 55 percent, but the corresponding increase in loan amounts was only 26 percent, implying the lender might have discounted their revealed creditworthiness as assessed by their groups and the federation. In the same vein, farmers that defaulted in the first year had their credit limits decreased by 92 percent and this led the lender to declare them ineligible.

Access to group loans reduced the capacity of farmers to engage in other borrowing, such that for the average farmer the amount of conventional credit decreased after they were able to participate in group loans. This not only reveals a preference for group loans over conventional credit but also indicates that farmers may be facing a notional overall credit ceiling for all types of borrowing. The crowding out effect has important implications because group loans differ from conventional loans in important ways. For example, while group loans were supposed to be used only for maize production, conventional loans had various uses and only about 50 percent were for agriculture. The repayment duration and interest rates also differs. The crowding out effect suggests that some part of group loans may be used for purposes that were met through conventional loans (school fees, medical expenses, business etc.). This would not only reduce the amounts invested in maize production but may also cause cash-flow problems if loans are diverted to activities that do not produce returns within a year.

APPENDIX

Table A1.1: Means of Loan Size from the Group lending Program and Credit from Other Sources

		Strata of Households in the Sample			
Variable	Year	No credit in Both years (a)	Received credit in 2007 only (b)	Received credit in both 2006 & 2007 (c)	Received in 2006 only (d)
Group loans received	2006	-	-	23382.47	23694.59
	2007	-	15760.98	28041.24	0
Loans from other sources	2006	7313.953	11701.03	4637.113	4459.459
	2007	7204.922	7012.371	3411.34	8621.622
Credit limit	2006	0	0	24613.4	24278.38
	2007	0	19302.06	38082.47	2162.162
Value of "collateral" (Kshs)		0	109197.8	93708.33	122606.3
Sample size		129	97	97	37

Table A1.2: Means of Village and Group Characteristics

		Strata of Households in the Sample			
Variable	Year	No credit in Both years (a)	Received credit in 2007 only (b)	Received credit in both 2006 & 2007 (c)	Received in 2006 only (d)
(a) Group level					
Initial Group size (at registration)		20.217	20.896	19.721	19.162
Members entry fee (Kshs)		3854.388	3345.206	3331.897	2792.135
Proportional turnover (Entry plus exit/group size)		.592	.676	.761	.631
Mean annual turnover		3.951	5.772	4.898	3.132
(b) Village level					
Number of primary schools	2007	1.193	1.226	1.072	1.135
Oldest school (years)	2006	23.410	27.020	22.216	18.324

Table A1.3: Means of Prices Received by Sampled Farmers

Variable	Year	Strata of Households in the Sample: No credit in Both years (a)	Received credit in 2007 only (b)	Received credit in both 2006 & 2007 (c)	Received in 2006 only (d)
Maize price at planting	2006	998.515	1081.649	1000.825	1019.459
	2007	975.193	966.391	1013.041	1025.135
Fertilizer price	2006	35.182	35.071	34.651	35.227
	2007	36.434	35.232	35.174	36.762
Land preparation cost	2006	1660.456	1654.376	1919.284	1717.117
	2007	1646.477	1801.5	1947.003	1725.837
Cost of seed	2006	112.334	111.333	114.988	114.045
	2007	115.208	126.557	117.775	113.054
Agriculture wage rate	2006	92.054	93.659	95.412	97.567
	2007	105.193	107.319	109.175	109.729

Table A1.4: Means of Household Characteristics

Variable	Year	Strata of Households in the Sample: No credit in Both years (a)	Received credit in 2007 only (b)	Received credit in both 2006 & 2007 (c)	Received in 2006 only (d)
Total landholdings	2006	6.319	5.557	5.975	5.376
	2007	6.320	5.642	6.178	5.633
Dist to fertilizer seller	2006	13.962	17.76	12.973	14.289
	2007	12.671	15.605	13.478	11.721
Dist to maize market	2006	6.841	8.945	7.418	9.856
	2007	6.618	8.739	7.439	10.127
Dist to “motorable” road	2006	.177	.094	.131	.094
	2007	.178	.094	.131	.094
Value of farm assets (Kshs)	2007	16682.95	19298.97	33949.48	22289.19
Household size	2007	2.566	2.297	2.582	3.485
Age of head of household		47.449	44.329	44.505	46.189
Education of head (years)		7.038	7.072	8.463	7.621
Proportion of female heads		.162	.123	.061	.135

Table A1.5: Means and Standard Deviations of Yield and Inputs in Maize Fields

Variable	Year	Strata of Households in the Sample: Ineligible in Both years (a)	Group received credit in 2007 only (b)	Group received credit in 2006 & 2007 (c)	Group received credit in 2006 only (d)
(a) Maize Harvest					
Maize yield (Kgs/acre)	2006	1942.332	1826.83	1879.12	1600.179
(b) Inputs					
Fertilizer Kgs per-acre	2006	91.2	92.84	110.53	83.05
(Maize Fields only)		(42.80)	(38.23)	(41.67)	(32.94)
	2007	85.91	105.75	109.28	82.13
		(52.95)	(56.40)	(58.21)	(32.95)
Fertilizer Kgs per-acre	2006	12.238	28.867	29.947	10.827
(Non-Maize Fields)		(28.905)	(67.743)	(64.773)	(25.410)
	2007	14.356	26.713	27.312	35.073
		(33.942)	(33.210)	(42.827)	(41.277)
Proportion of fertilizer in maize	2006	.77	.90	.94	.97
Nitrogen Kgs per-acre	2006	21.859	19.545	26.266	16.570
		(30.136)	(9.636)	(12.185)	(7.371)
	2007	16.787	21.808	21.317	15.796
		(13.946)	(13.172)	(14.272)	(10.020)
Acreage under maize	2006	2.301	2.412	3.308	2.602
		(2.752)	(2.524)	(2.108)	(1.655)
	2007	2.286	2.3558	3.321	2.491
		(2.836)	(1.831)	(2.195)	(1.730)
Hybrid seed rate	2006	10.384	13.355	11.356	12.093
		(3.095)	(9.621)	(6.545)	(10.839)
	2007	10.662	10.46	10.235	10.178
		(4.329)	(4.126)	(8.780)	(.908)
Labor rate	2006	16.305	15.993	18.917	19.629
		(15.598)	(13.096)	(15.083)	(13.293)
		(1467.453)	(1037.168)	(1070.532)	(759.317)
Sample size		**129**	**97**	**97**	**37**

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CHAPTER TWO: THE IMPACT OF AGRICULTURAL CREDIT ON DEMAND FOR FERTILIZER AND SEED IN RURAL KENYA

2.1. Introduction

Agricultural productivity in Sub-Saharan Africa is among the lowest in the world. Yields are relatively lower for most crops, including cereals which occupy most of the cultivated area (see figure 2.1). Low agricultural productivity in sub-Saharan Africa could partly be explained by low use of fertilizers (Sheahan, Black, and Jayne, 2013). According to the International Fertilizer Development Centre (IFDC) nitrogen consumption in sub-Saharan Africa in 2006/07 stood at 9 Kg/Ha compared to 44 Kg/Ha in South Africa, 94 Kg/Ha in Latin America, 115 Kg/Ha in South Asia, and a world average of 118 Kg/Ha. Recent literature suggests that poor infrastructure could increase the cost of transport to the extent that new technology becomes unprofitable, even for farmers with high marginal returns (Suri, 2012). Another strand of the literature suggests that low consumption of fertilizers in Sub-Saharan Africa is linked to lack of working capital (credit constraints) and inability of farmers to insure production risks due to missing markets for crop insurance (see Kelly, 2006; Poulton, Kydd et al., 2006; Gerhart, 1975; Wekesa, Mwangi et al., 2003; and Shalit and Binswager, 1984). Fertilizer application rates are generally higher in irrigated agriculture than less-risky rainfed conditions (Jayne and Rashid, 2013).

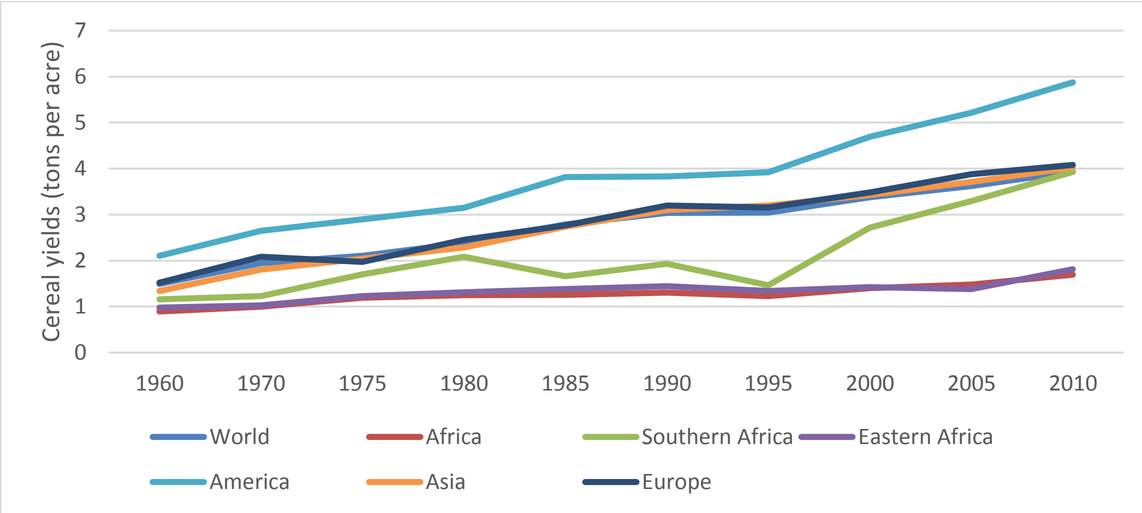
This chapter evaluates the impact of an agricultural group credit program in Kenya on demand for fertilizer nutrients (nitrogen, potassium, and phosphorous) and hybrid seeds. The impact on demand for labor is evaluated in chapter 3 and the impacts on maize output and profits from maize farming are evaluated in chapter 4. The group credit program was financed by the Agricultural Finance Corporation of Kenya (AFC), which is a government owned bank with a mandate to finance investments in agriculture. The program involves farmers applying for loans through their farming groups. The groups are affiliated to the Kesses Division Farmers Marketing Federation (KDFMF) – an apex organization of farmer groups in Kesses division, Uasin Gishu district. The KDFMF underwrites the loans. A detailed description of the group loans program is provided in Chapter One. The study area is a high potential agriculture zone where maize production is among the most important sources of farm income. The credit program is a deliberate effort to help farmers resolve working capital constraints and purchase productive inputs for maize cultivation.

Empirical studies on the relationship between credit constraints and farm outcomes have found mixed results. Guirkinger and Boucher (2008) employ switching regression models to estimate the impact of credit constraints on agriculture productivity in Peru. Their results suggest that credit constraints lower the value of agriculture output in Peru by about 26 percent and they conclude that credit is a major impediment to agricultural growth. Similar results were found in a study conducted in Pakistan by Sial and Carter (1996) where they conclude that an individual selected randomly from a sample of farmers in the Punjabi region would produce 48 percent more output if given an average sized loan. Credit constraints are relatively more severe among smallholder farmers in Pakistan (Khandker and Faruqee, 2003). Ordinarily, credit would not be provided without cost to a borrowing farmer so positive impacts on farm output do not necessarily mean increased farm profits. Foltz (2004) examines the effect of credit on farm profits using data from a sample of farmers in Tunisia. The results indicate the elasticity of profits with respect to credit is 0.20 for rationed farmers and 0.04 for non-rationed farmers, which leads to a conclusion that better access to credit would significantly improve farm profits for rationed farmers. Another strand of literature finds a weak relationship between credit constraints and farm outcomes. Carter (1989) found that access to credit hardly impacts production from small farms in Nicaragua. The study concludes that credit cannot be expected to reduce structurally unbalanced growth in Nicaraguan agriculture. These findings are similar to Feder et al., (1990) who found marginal impacts of credit on agricultural output in China and concluded that credit may be more beneficial when diverted to consumption and small-scale investments instead of agricultural production.

These mixed results suggest that the impact of credit on agricultural outcomes could vary greatly from one location to another and any findings from one location may not be externally valid. Notwithstanding this limitation, the findings provide important location-specific insights on the potential to increase agricultural production and farm profits through agricultural credit. A fundamental limitation of the previous studies is they rely on methods that provide limited information on the pathways through which access to credit may improve agricultural production and farm profits.

The main contribution of this paper is to develop and employ an estimation strategy that allows tracing the pathways through which agricultural credit could impact production and farm profits. We estimated the impact of group credit on demand for nitrogen, phosphorous and potassium combined, and hybrid seed use. Two estimation approaches were used. In section 2.4.2 we estimate linear approximations for factor demand equations suggested by theory (section 2.2). For robustness checks we also estimate the average treatment effects (ATE) using approaches in the evaluation literature (section 2.2). Results from the two approaches are consistent. They show that group credit increased demand for nitrogen nutrients in fertilizers but had no impacts on demand for phosphorous and potassium nutrients or hybrid seeds. With regard to impact on demand for nitrogen the linear approximations of demand equations suggest an increase of 43.65 percent from pre-borrowing levels while the ATE estimates an increase of 30.55 percent.

Figure 2.1: Comparative cereal yields (1960 – 2010)



Source: FAOSTAT

2.2. Theoretical Framework

This section develops a theoretical model to evaluate the impact of group credit on; (i) demand for inputs to cultivate maize, (ii) maize yields, and (iii) profits from maize cultivation. Consider a farmer cultivating maize using a technology $F(X, L: K)$, where X is a vector of factors that vary with plot size (e.g. fertilizers and seeds), L is plot size measured in acres, and K are inputs that do not vary with plot size e.g. skills and knowledge about farming. We assume that maize production exhibits constant returns to scale (CRS) in land. This implies the per-acre production function can be written as $f(x; K) \equiv F\left(\frac{X}{L}, 1;\ K\right)$, where $x \equiv \frac{X}{L}$ is the per-acre vector of inputs. Per acre profits from maize cultivation are:

$$\pi(x, ; K) = pf(x; K) - wx - l - r_c C - r_g G \qquad (2.1)$$

where, p is price of maize output, w is price of factors such as seeds and fertilizers, l is the rental rate for one acre of land, r_c is cost of credit from conventional sources, r_g is cost of group credit, C is conventional loans, and G is group loan. Both C and G are per unit land. Interest rates r_c and r_g are non-zero partly because loans are not fully collateralized and the market for credit is not perfectly competitive.

Lenders do not ex-ante have perfect information about each famer's ability to repay as there is no repository of information about credit histories of prospective borrowers. While there may be data on personal attributes of farmers or characteristics of plots cultivated by farmers, the data is not summarized into a commonly understood measure of creditworthiness such as a credit score. Furthermore, while some of this information could be collected through a costly loan application process, borrowing farmers may still have private information after receiving loans – for example on the effort they put in crop management. Therefore moral hazard remains a problem. The presence of moral hazard means lenders in both conventional and group credit schemes cannot perfectly differentiate between "high-risk" and "low-risk" borrowers. This inability to differentiate high and low risk borrowers leads lenders in conventional credit to offer a uniform rate of interest r_c to borrowers. Similarly, borrowers in the group credit program are offered a uniform rate of interest r_g. Therefore, interest rates are exogenous to an individual borrowing farmer in conventional credit as well as the group credit program under evaluation.

The function $f(x; K)$ is strictly concave. The CRS technology implies that there is a unique profit maximizing vector of inputs per-acre, denoted x^*, which is independent of maize acreage cultivated. We further assume that land quality is homogenous across plots in the study area. However, in the empirical application we control for plot differences using variables such as crop mix (monocrop or intercrop) and use of tractor in land preparation – which is a function of plot characteristics such as land elevation and drainage as well as availability of working capital. Plot homogeneity does not mean farmers use the profit maximizing vector of inputs because of working capital constraints.

The working capital constraint for maize cultivation per acre is written as:

$$wx \leq C + G + E \tag{2.2}$$

where, C is amount of conventional credit, G is amount of group credit, and E is wealth. Equation 2.2 assumes that a farmer has to borrow if they want to spend more on inputs than what is available from current wealth. Notice that the constraint in equation 2.2 is for maize cultivation expenditures. A credit contract specifies loan amount, interest rate, and collateral requirements. Lenders under conventional credit would require collateral in prime assets such as titled land or motor vehicles. These requirements are beyond the reach of most farmers in the study area because they are small scale, rely predominantly on rainfed agriculture for livelihoods, and are therefore less likely to risk land for seasonal credit. It is this limited ability to provide collateral for individual loans from conventional lenders that led farmers to mobilize and form farmer groups that would (among other activities) seek agricultural loans under joint liability contracts. The lender in the group scheme does not require collateral from individual famers or their groups, but rather an underwriting from the apex federation organization of their groups – the KDFMF. However, groups require borrowing members to quasi-collateral to the group (not the lender) in form of commonly found liquid assets such as furniture, radio, farm tools, commercial trees in the farm etc. (The group lending process is discussed in more detail in Chapter 1).

The above framework will be applied to measure the impact of access to credit on fertilizer and hybrid seed use without distinguishing between credit constrained and non-constrained farmers. Consider the case where the working capital constraint equation (2.2) is binding. The amount a farmer could borrow from conventional sources C is limited by several factors, including land owned A, salaried income S, and fixed assets T. We write per-acre conventional credit as $C(A, S, T)$. On the other hand, the amount a farmer could borrow from group sources G is limited by a per-acre credit limit M that is exogenously imposed by the group, and the value of liquid household assets N required by groups as quasi-collateral. The per-acre group credit is written $G(M, N)$. It means when we observe an incidence of borrowing it does not mean a farmers credit constraints are fully resolved because conventional and group loans are rationed by $\mathrm{A, S, T, M, N}$. Similarly, lack of borrowing does not mean a farmer is not credit constrained because $\mathrm{A, S, T, M, N}$ could crowd-out a farmer out of both conventional and group loan markets. Therefore, participation in any credit market – whether conventional or a group borrowing program – does not reveal whether a farmer is credit constrained or not. Furthermore, that distinction is uninteresting because suppliers of credit – whether conventional or a group borrowing program –would not target loans based on who is actually credit constrained, but rather on the ability of prospective farmers to repay. What really matters is to understand the impact of credit on farm outcomes and not whether those taking loans are credit constrained or not.

A profit maximizing farmer will choose x subject to the working capital constraint equation (2.2). The solution is profit maximizing factor demands that depend on K, C, G and prices for inputs and outputs. The vector of optimal factor demands can be written:

$$x^*(p, w, K, C(A, S, T), G(M, N), E) \qquad (2.3)$$

And the corresponding maize yield function (output supply function per acre) can be written

$$y^*\big(., G(M, N)\big) = f\big[x^*\big(., G(M, N)\big)\big] \qquad (2.4)$$

where (.) is used for variables other than group credit to avoid notational clutter. The farmer realizes per-acre profits equal to

$$\pi^*[., G(M,N)] = p\, f\{x^*[., G(M,N)]\} - wx^*[., G(M,N)] - l - r_c C(A,S,T) - r_g G(M,N) \quad (2.5)$$

The profit impact of access to group credit could be examined using equation (2.5). Access to credit improves working capital available to a farmer. Therefore, we take derivatives of equation (2.5) with respect to group credit G to get

$$d\pi^*/_{dG} = p\sum_{i=1}^{j}\left(f_i \times {dx_i^*}/_{dG}\right) - \sum_{i=1}^{j} w_i \times {dx_i^*}/_{dG} - r_g = \gamma^* \quad (2.6)$$

Where ${dx_i^*}/_{dG}$ is the impact of group credit on demand for inputs per-unit land (e.g. fertilizer and seed rates), f_i is the marginal productivity of input i, and γ^* is net impact of group credit on maize profits per-acre. The impact of group credit on maize productivity of any input *i* is given by the product of $f_i(.)$ and ${dx_i^*}/_{dG}$. The monetary value of incremental yield is obtained by multiplying the marginal impact on the sum of maize input productivities with the price of maize grain $p\sum_{i=1}^{j}\left(f_i \times {dx_i^*}/_{dG}\right)$. The marginal cost of increased demand for inputs is calculated from $\sum_{i=1}^{j} w_i \times {dx_i^*}/_{dG}$ and the cost of group loans is r_g.

2.3. Estimating the Impact of Group Credit on Demand for Fertilizer Nutrients and Seeds for Maize Cultivation

2.3.1. Factor Demand Equations

The impact of group credit on factor demands will be estimated using the demand equations suggested by the theoretical model (section 2.2). The optimal factor demands were given in equation 2.3 thus:

$$x^*(p, w, K, C(A, S, T), G(M, N), E)$$

Where x^* is the profit maximizing choice of factors (fertilizer nutrients and seeds) per unit land, K are inputs that do not vary with plot size e.g. skills and knowledge about farming, p is price of maize grain, w is price of factors such as seeds and fertilizers, C is conventional loans per unit land, and G is group loan per unit land.

The production function assumed to be underlying the above demand functions is translog (see chapter 4 for a discussion on the selection criteria applied to choose competing functional forms). Input demand functions for the translog are highly non-linear and the structural parameters can be hard to estimate. To address the problem we estimate a linear approximation of the factor demands written:

$$x_{ijlt} = \alpha_t + B_{iijt}\theta + K_{iijt}\beta + C_{ijlt}(.)\varphi + G_{ijlt}(.)\gamma + E_{ijlt}\partial + F_j + F_l + F_i + v_{iijt} \quad (2.7)$$

where, subscript i, j, l, t respectively denote farmer, village, group, and season. B_{ijlt} is a vector of output and input prices comprising of maize grain prices at the time of purchasing inputs, price of fertilizers, and price of seed. The corresponding vector of parameters is given by θ. α_t is time-changing due to seasonal factors such as rainfall. To avoid clutter we use the notation (.) to depict possible dependence of group credit and conventional loans on other variables as discussed previously. In estimating equation 2.7 we use dummies for salaried income and informal income to proxy for wealth.

Farmers are price takers in input and output markets and so the vector B_{iljt} is assumed to be exogenous. The vector K_{ijlt} accounts for skills and knowledge about farming. It is measured by level of education and age of the head of the household. These variables are not determined by decisions about agricultural production and therefore are expected to be exogenous. The variables F_j, F_l, and F_i represent village, group, and farm fixed effects respectively. v_{iijt} is a disturbance term.

The impact of group credit on demand for inputs (seeds and fertilizers) is given by the parameter γ. The amount of conventional loans C_{ijlt} and group loans G_{ijlt} is potentially endogenous for various reasons, including self-selection into borrowing from either source. To address the endogeneity problem we use instrumental variables. The instruments for conventional loans C_{ijlt} are total landholding A_{ijlt} and value of fixed assets T_{ijlt}. And the instruments for group loans G_{ijlt} are the value of commonly found assets that are used as collateral in group borrowing arrangements N_{ijlt}. Equation 2.7 is estimated using two-stage least squares on differenced data (2007-2006) to eliminate fixed effects and obtain efficient estimates. The estimating equations are:

$$x_{ijlt} - x_{ijlt-1} = \alpha_t - \alpha_{t-1} + (B_{iijt} - B_{iijt-1})\theta + (K_{iijt} - K_{iijt-1})\beta + (C_{ijlt} - C_{ijlt-1})\varphi + (G_{ijlt} - G_{ijlt-1})\gamma + (E_{ijlt} - E_{ijlt-1})\partial + (v_{iijt} - v_{iijt-1}) \quad (2.8)$$

The full sample data from all strata is used for estimation, including stratum (a) households that were ineligible for group credit in both years, stratum (b) households that were ineligible in 2006 but became eligible and received group loans in 2007, stratum (c) households that were eligible and took group loans in both years, and stratum (d) households that obtained group loans in 2006 but defaulted and were declared ineligible in 2007. (Detailed description of the data is provided in Chapter 1 section1.5). The results are presented in table 2.4 for impact of group loans on demand for fertilizer nutrients and hybrid seeds.

2.3.2. Results for Factor Demand Estimates

This section reports estimates of the demand equations for nitrogen, phosphorous and potassium, and hybrid maize seeds. The amount of nitrogen, phosphorous, and potassium is calculated from the ratio of these nutrients in various fertilizers. For example, in both years the most commonly used basal fertilizer was Diammonium Phosphate (DAP) 18:46:0 – which means the ratio of nitrogen, phosphorous, and potassium in one kilogram is 18:46:0. Other commonly used basal fertilizers were NPK 23:23:23 – a balanced fertilizer, NPK 23:23:0, and NPK 20:10:10. More than 93 percent of the farmers that applied top dressing fertilizers used either Calcium Ammonium Nitrate (CAN) 26:0:0 or Urea 46:0:0 or Sulphate of Ammonium 21:0:0 – all of which contain only nitrogen nutrients. This explains the higher consumption of nitrogen nutrients relative to phosphorous and potassium. The results are summarized in table 2.4 below. The explanatory variables are conventional loans, group loan, price of maize at planting, price of fertilizers, wage rate, seed cost per kilogram, distance to seller of fertilizers, distance to the market, distance to motorable road, informal income dummy, salaried income dummy, age of household age, squared age of household head, education of household head, female headed households dummy, age of oldest primary school in the village, number of primary schools in the village, age of group since registration, proportional turnover in the group – sum of exit and entry as a proportion of initial group size.

Conventional loans and group loans are potentially endogenous. This problem is addressed by using the instrumental variables approach. The instruments for conventional loans are total landholding and value of assets. The instrument for group loan is value of assets provided as security to the group. The equations are estimated using two stage least squares in STATA – the *ivregress* command. The results indicate that one Kenya Shillings (KES) per acre of group loan increased demand for nitrogen nutrients by 0.001 kilograms per-acre. The null hypothesis that group credit has zero effect on demand for fertilizers is rejected at the 10% significance level. Pre-borrowing mean nitrogen application rate was 19.54 Kgs per-acre (see table 1.5). The average group loan size per acre is KES 8,529.29. Therefore, an average farmer receiving group credit increased nitrogen demand by 8.53 Kgs per acre (0.001*8,529.29). We conclude that group credit increased fertilizer demand by about 43.65 percent from pre-borrowing levels.

The procedure used to estimate the impact on demand for phosphorous (P) and potassium (K) is similar to what we followed regarding nitrogen. The dependent variable is sum of phosphorous and potassium per acre and the explanatory variables are exactly the same as in the nitrogen equation. We combined these nutrients because they were used in fixed proportions across the sample (see figure 4.3 on chapter 4) and having both of them would cause multicollinearity. The results are in second column of table 2.4. The coefficient for P+K is negative but not statistically significant so we fail to reject the null hypothesis that group credit had zero impact on demand for P+K. This leads to a conclusion that group credit did not influence demand for P+K. The same conclusion could be reached with respect to the effect of conventional loans on demand for P+K.

The dependent variable for the results in the last column of table 2.4 is demand for hybrid maize seeds, which refers to the seed rate (kilograms per acre) rather than the decision to switch from non-hybrid to hybrid. The study region is located in the high potential maize zone and a majority of farmers already use hybrid seeds. In our sample, all farmers used purchased (new) hybrid seeds in at least one field, and 98 percent of the fields were planted with purchased hybrid seeds. Retained hybrid seeds, which refers to seeds kept from previous harvests, accounted for about 1 percent of the fields. There was no farmer planting local varieties. The explanatory variables are exactly as in the equations for fertilizers and land to cultivate maize. We fail to reject the null hypothesis that group credit has zero impact on demand for hybrid seeds. Farmers in the study have long been exposed to hybrid seeds.

In summary, the results indicate that (i) group credit increased demand for nitrogen by 43.65 percent from pre-borrowing levels, (ii) there was no impact on demand for P+K, (iii) there was no effect on demand for hybrid seeds, and (iv) the effects of group credit and conventional loans are quite different and therefore these sources of working capital should not be aggregated in estimations designed to evaluate credit impacts. Nutrients are not sold separately so it's hard obtaining a disaggregated price for different nutrients. However, of all the three nutrients it is nitrogen that is applied in the highest amounts – see scatterplots in chapter 4 figure 4.3 – such that the results of the stochastic frontier model in chapter 4 indicate that the marginal physical product and marginal revenue product for nitrogen are lower than for P+K. The simple approach we take is to use the cost of fertilizer per-kg as the imputed cost of nitrogen. The price of fertilizer is KES 35.08 per kilogram. The average farmer cultivated 2.41 acres of maize. Multiplying this by the incremental demand for an average borrowing farmer (8.53) we get incremental total cost of fertilizers equal to KES 721.15 (35.08*2.41*8.53).

The effect of maize prices on demand for fertilizer nutrients and seeds is not significant. To understand these results it is important to remember that the study area is a high potential maize zone where all farmers plant maize in the main cropping season. Maize hardly competes with another crop. In this production environment, it is unlikely that normal or small inter-seasonal changes in maize prices would affect farmer's behavior in input markets. The price of fertilizers has significant negative effect on demand for P+K and seeds but not for nitrogen. Fertilizer nutrients are not sold separately. Most fertilizers contain some portions of nitrogen, P, and K – except for top-dressing fertilizers that mostly contain only nitrogen. Furthermore, the scatterplot on figure 4.3 indicates that farmers use more nitrogen than P+K combined, which suggests that farmers may be buying fertilizers for their nitrogen content. Assuming nutrients in fertilizers are priced the same, which is the inherent assumption in the data used for estimations, it would make sense that fertilizer price would have a negative effect on the less demanded nutrients (P+K) and small effect on the nutrient for which farmers are buying fertilizer – nitrogen.

We find that access to markets matters in factor demands. Farmers that are relatively further from a fertilizer seller have less demand for nitrogen as well as P+K but not seeds. However, once we control for distance to fertilizer seller the other infrastructure variables (distance to maize market and distance to motorable road) are not statistically significant, although their coefficients suggest the expected negative relationship. We use a salaried income dummy and informal income dummy to proxy for a famer's wealth. Both variables are not statistically significant in the input demand equations although the coefficients suggest a positive relationship. The coefficient of the female household dummy is negative and significant in the nitrogen equation, which indicates that female-headed farming households are using less of nitrogen (the most demanded nutrient) than male-headed households. Overall, the statistically significant variables explain more than 80 percent of the variation of factor demands.

Table 2.4: Impact of group credit on demand for nutrients and hybrid seed

	Nitrogen	P+K	Seed
Conventional credit	-0.00020	-0.00019	0.00006
	(0.71)	(1.12)	(0.75)
Group loans	0.00110	-0.00038	-0.00031
	(1.81) +	(1.34)	(0.87)
Maize price	-0.0043	0.00112	-0.00051
	(1.39)	(1.23)	(0.75)
Fertilizer price	0.0214	-0.1248	-0.1494
	(0.08)	(1.84)+	(1.89)+
Wage rate	-0.0417	0.0403	-0.0201
	(0.33)	(1.15)	(0.89)
Cost of seed	0.0266	-0.0030	-0.0091
	(0.89)	(0.40)	(0.97)
Distance to fertilizer	-0.3505	-0.1706	0.0794
	(1.89) +	(1.76)+	(0.89)
Distance to maize market	-2.3023	0.5199	0.0752
	(1.57)	(1.27)	(0.41)
Distance to motorable road	-11.8611	-0.5698	-0.0719
	(1.43)	(0.18)	(0.05)
Informal income dummy	5.6750	0.0790	1.5206
	(1.12)	(0.05)	(0.97)
Salaried income dummy	10.3003	0.3224	2.0415
	(1.51)	(0.15)	(1.11)
Age of head	-1.4306	-0.1028	-0.0035
	(1.23)	(0.35)	(0.01)
Age of head squared	0.0160	0.0003	0.0009
	(1.31)	(0.10)	(0.28)
Education of head	0.9067	0.2867	0.0482
	(1.27)	(1.46)	(0.31)
Female head dummy	-11.6260	-1.1534	0.2216
	(2.00)*	(0.65)	(0.16)
Age of oldest school	-0.0296	-0.0337	-0.0530
	(0.13)	(0.36)	(1.02)
Number of primary schools	-3.2961	-0.6265	0.8817
	(0.57)	(0.30)	(0.82)
Group size at registration	-0.1836	0.2349	-0.1393
	(0.29)	(0.94)	(0.91)
Group age	-0.2457	0.4453	-0.1579
	(0.29)	(1.34)	(1.08)
Proportional turnover	-4.0090	2.0006	1.4397
	(0.68)	(1.31)	(0.96)
Constant	-16.1638	2.3597	1.7174
	(0.39)	(0.19)	(0.18)
Adjusted R-squared	0.83	0.83	0.83

The significance levels are:+ $p<0.1$; * $p<0.05$; ** $p<0.01$ and Z statistic in parenthesis

2.3.3. Average Treatment Effects

This section describes estimation of the Average Treatment Effect (ATE) on demand for nitrogen, phosphorous and potassium, and hybrid maize seeds. The estimates from the linear approximations in the previous section provide the expected change in demand for inputs from one shilling of group loan. The ATE estimates the expected impact on demand for inputs when a farmer moves from not receiving group credit to receiving group credit. The two approaches provide different estimators for the impact of group credit and so can be used as a consistency check for results.

As described in the group lending process (Chapter 1 section 1.3) participation of a farmer in group lending is a decision made by the federation and lender for the entire group a farmer belongs to – not on an individual basis. But it is individual farmers (not a group) that makes input decisions, cultivates land, and engages in maize production. Therefore the ATE measures the average (expected) impact on a farmer participating in the group credit program. Let PG_{lt} denote participation of group l at season t. Conditioned on PG_{lt}, the level of fertilizers and seeds demanded by a farmer could be written

$$x_{ijlt} = \alpha_t + B_{iijt}\theta + K_{iijt}\beta + PC_{it}\delta + PG_{lt}\pi + E_{ijlt}\partial + F_j + F_l + F_i + e_{iijt}$$

(2.9)

where, PC_{it} is farmer participation in non-group credit and e_{iijt} is an error term satisfying $E\left(e_{iijt} \,\middle|A_{ijlt}, K_{iijt}, E_{ijlt}, P_{ict}, P_{gt}\right) = 0$. α_t is time-changing due to seasonal factors such as rainfall. Differencing the above equation gives:

$$x_{ijlt} - x_{ijlt-1} = \alpha_t - \alpha_{t-1} + \left(B_{iijt} - B_{iijt-1}\right)\theta + \left(K_{iijt} - K_{iijt-1}\right)\beta + (PC_{it} - PC_{it-1})\delta + (PG_{lt} - PG_{lt-1})\pi + \left(E_{ijlt} - E_{ijlt-1}\right)\partial + \left(e_{iijt} - e_{iijt}\right) \quad 2.10$$

Equation 2.10 is estimated using Ordinary least squares (OLS) to obtain a consistent estimate of the ATE. In the estimating equation an informal income dummy and salaried income dummy are used as proxy for wealth.

2.3.4. Results for Average Treatment Effects

This section reports estimates of the average treatment effect (ATE) of group credit on demand for nitrogen, phosphorous and potassium, and hybrid maize seeds. The ATE is estimated using a differenced model and the differencing period is (2007-2006). The results are summarized in table 2.5 below. The explanatory variables are treatment dummy (which measures the ATE), amount of conventional credit, price of maize at planting, price of fertilizers, wage rate, seed cost per kilogram, value of assets, distance to seller of fertilizers, distance to the market, distance to motorable road, informal income dummy, salaried income dummy, age of household age, squared age of household head, education of household head, female headed households dummy, age of oldest primary school in the village, number of primary schools in the village, age of group since registration, proportional turnover in the group – sum of exit and entry as a proportion of initial group size.

The results indicate that group credit increased nitrogen demand on average by 5.97 kilograms per-acre. The null hypothesis that group credit has zero effect on demand for nitrogen is rejected at the 5% significance level. Pre-borrowing mean nitrogen application rate was 19.54 Kgs per-acre (see table 1.5). Therefore, we conclude that group credit increased nitrogen demand by about 30.55 percent from pre-borrowing levels. The procedure used to estimate the impact on demand for P+K is similar to what we followed regarding nitrogen. And the explanatory variables are exactly the same as in the fertilizer equation. The results are in second column of table 2.5. The coefficient for P+K is negative but not statistically significant so we fail to reject the null hypothesis that group credit had zero impact on demand for P+K. This leads to a conclusion that group credit did not influence demand for P+K. The same conclusion could be reached with respect to the effect of conventional loans on demand for P+K.

The dependent variable in the results in the last column is demand for hybrid maize seeds, which refers to the seed rate (kilograms per acre) rather than the decision to switch from non-hybrid to hybrid. The study region is located in the high potential maize zone and majority of farmers already use hybrid seeds. In our sample, all farmers used purchased (new) hybrid seeds in at least one field, and 98 percent of the fields were planted with purchased hybrid seeds. Retained hybrid seeds, which refers to seeds kept from previous harvests, accounted for about 1 percent of the fields. There was hardly a farmer planting local varieties. The explanatory variables are exactly as in the equations for fertilizers and land to cultivate maize. We fail to reject the null hypothesis that group credit has zero impact on demand for hybrid seeds. Farmers in the study have long been exposed to hybrid seeds.

The difference between the estimating equations for ATE and linear demand equations is that in the ATE group credit is represented by a participation dummy rather than group loan amounts. All other variables are defined exactly the same. It means the ATE is estimated with less variation in the data. The results indicate that the reduced variation in the data leads to some changes in the statistical significance of several variables although the direction of effects largely remain unchanged. For example, the price of fertilizer is no longer significant in the P+K equation although the coefficient is still negative. But the effect of fertilizer prices continues to be significant and negative in the seed equation. There are no changes in the coefficient on maize prices as it continues to have no effect on demand for all inputs. The direction of effects for distance to fertilizer seller continues to be negative but it’s no longer statistically significant.

Another change is with regard to the coefficient on the female headed dummy, which has now lost statistical significance in the nitrogen equation but continues to be negative. These changes are translated into reduced fit to the data as reflected in lower adjusted R squared.

Table 2.5: ATE of group credit on demand for nitrogen, phosphorous and potassium, and improved seed

	Nitrogen	P + K	Seed
Group credit dummy	5.97	-0.82	-0.07
	(2.33)*	(0.74)	(0.08)
Conventional credit	0.00002	-0.00006	0.00000
	(0.74)	(1.80)+	(0.39)
Maize price	-.000001	.000001	-.00004
	(1.19)	(0.30)	(1.39)
Fertilizer price	-0.3299	-0.0217	-0.0860
	(1.19)	(0.15)	(1.70)+
Wage rate	0.0310	0.0223	-0.0262
	(0.45)	(0.75)	(2.41)*
Cost of seed	0.0206	0.0205	-0.0054
	(0.59)	(1.16)	(0.88)
Distance to fertilizer	-0.1620	-0.0194	-0.0863
	(1.15)	(0.27)	(1.51)
Distance to maize market	0.3116	0.3981	0.0139
	(0.65)	(1.25)	(0.15)
Distance to motorable road	1.9087	2.4507	-0.3824
	(0.45)	(1.19)	(0.64)
Informal income dummy	-10.3098	-3.5720	-0.3724
	(1.35)	(0.87)	(0.41)
Salaried income dummy	-7.0548	-3.8452	-0.2415
	(0.91)	(0.91)	(0.27)
Age of head	-0.7118	-0.0871	0.2181
	(1.19)	(0.38)	(1.27)
Age of head2	0.0078	0.0015	-0.0019
	(1.30)	(0.65)	(1.14)
Education of head	0.4038	0.1859	0.0762
	(1.40)	(1.43)	(1.33)
Female head dummy	-13.8553	-7.7795	0.6509
	(1.10)	(1.11)	(0.42)
Age of oldest primary school	-0.2347	-0.0790	-0.0504
	(1.51)	(0.98)	(1.25)
Number of primary schools	3.7559	2.9103	1.1230
	(1.04)	(1.50)	(1.36)
Group size at registration	-0.2962	-0.0106	-0.0251
	(0.98)	(0.07)	(0.49)
Group age	1.2769	1.2672	-0.0605
	(0.80)	(1.43)	(0.45)
Proportional turnover	3.4119	1.0404	1.1259
	(1.38)	(0.90)	(1.66)+
Constant	16.1968	-5.7122	-4.8272
	(1.02)	(0.93)	(1.09)
F statistic	0.1	0.1	0.1
Adjusted R-squared	0.21	0.14	0.10

The significance levels are: + p<0.1; * p<0.05; ** p<0.01, Z statistic in parentheses

2.4. Conclusions

In this chapter we estimated the impact of group credit on demand for nitrogen, phosphorous and potassium, and hybrid seed. Two estimation approaches were used. In section 2.3.2 we estimated linear approximations to the factor demand equations suggested by theory (section 2.2). For robustness checks we also estimated the average treatment effects (ATE) in section 2.3.3 using approaches in the evaluation literature and theory (section 2.2). The results of two approaches are consistent in that they show that group credit increased demand for nitrogen, but had no effect on demand for phosphorous and potassium and demand for hybrid seed. With regard to impact on demand for nitrogen the linear approximations give an increase of 43.65 percent from pre-borrowing levels while the ATE gives an increase of 30.55 percent from pre-borrowing levels. While the ATE was estimated as a robustness check for the linear approximations the estimator potentially uses less data as it reduces group loan amounts into a participation dummy. We therefore prefer results from the linear approximations and conclude that group credit increased demand for nitrogen by 43.65 percent. However, this effect of 43.65 percent also falls within the confidence intervals of the ATE estimate, which gives confidence that the magnitude of effect we have used is robust to alternative estimation approaches.

This work makes an important contribution to the literature on the relationship between credit constraints and agriculture production. We develop a theoretical model that allows examining not only impacts of agricultural loans on output and profit but also the pathways through which access to credit affects output supply. This approach provides a fuller understanding of the extent to which innovations in rural financial markets could improve demand for factors, production, and profitability. We conclude that increased demand for fertilizer is the pathway through which credit may lead to better farm outcomes and profitability.

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CHAPTER THREE: THE IMPACT OF GROUP CREDIT ON WAGE LABOR AND OWN CHILD LABOR IN RURAL KENYA

3.1. Introduction

Rural wage labor markets could provide an important pathway out of poverty. In many developing countries a large proportion of productive land is owned by a small proportion of households. The remaining households tend to have limited access to land and more labor than is required to cultivate the land they have. A functioning rural wage labor market could develop economic linkages between those holding productive land and their resource-poor neighbors who are often endowed with excess labor. Such linkages should enable excess labor in resource-poor households to earn wage income and improve economic wellbeing of poorer households. In rural Kenya per-capita access to land decreases as household size increases (see figure 3.1) which suggests small farm families may have excess labor that could potentially be absorbed by medium and large-scale farmers. Similar relationships have been observed in other countries. For example, Bardhan (1984) found a negative relationship between access to cultivable land and supply of agricultural labor in India. Rural credit markets could play an important role in the labor market because access to credit allows farmers to obtain the necessary working capital to pay for various factors of production, including labor.

This paper examines the relationship between agricultural credit markets and rural wage labor markets in rural Kenya. In particular, the paper uses a quasi-experiment based on a group credit program to estimate the impact of access to agricultural credit on demand for hired adult labor and own child labor. The group credit program was financed by the Agricultural Finance Corporation of Kenya (AFC) – a government owned bank with a mandate to finance investments in agriculture. The program involves farmers applying for loans through their farming groups.

The groups are affiliated to the Kesses Division Farmers Marketing Federation (KDFMF) – an apex organization of farmer groups in Kesses division, Uasin Gishu district. The borrowing process involves KDFMF underwriting the loans. The lender is the Agriculture Finance Corporation of Kenya (AFC). A detailed description of the group loans program is provided in Chapter One. The study area is a high potential agriculture zone where maize production is among the most important sources of farm income. The credit program is a deliberate effort to help farmers resolve working capital constraints and purchase productive inputs for maize cultivation.

There is evidence that when credit and insurance markets are incomplete, income shocks lead households to adopt self-insurance mechanisms that often involve diverting child time to labor activities at the expense of schooling (see Jacoby and Skoufias, 1997; Duryea, 1998; Jensen, 2000; Beegle, Dehejia et al., 2006; Kazianga, 2006). These findings suggest that functioning credit and insurance markets may contribute to long-term human capital development by allowing parents to keeping children in school. Many studies have shown theoretical links[8] between credit markets and child labor, but there has been little empirical work to test the relationships (see Brown, Deardorff, and Stern, 2001 for a review of theory and evidence). Furthermore, studies that have empirically tested for this relationship use country aggregate data (e.g. Dehejia and Gatti, 2005), which make it difficult to interpret the relationships as causal. In this paper we use a quasi-experiment based on a group credit program to estimate the causal effect on demand for child labor in maize production at the household level.

[8] Recent theoretical works on the relationship between credit constraints and child labor include (Parsons and Goldin 1989; Ranjan 1999, 2001; Baland and Robinson, 2000; and Jafarey and Lahiri 2002)

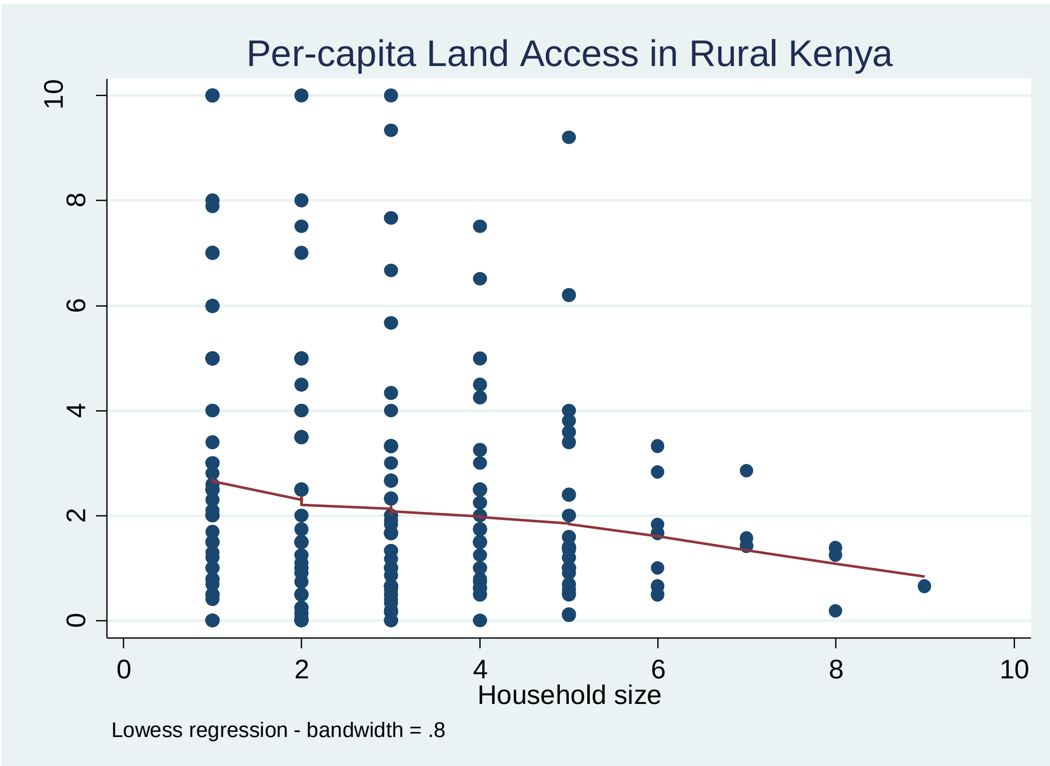
The paper makes two important contributions to the literature. The first contribution is that we examine whether access to production credit leads to reduced demand for child labor, which would then free child time for investments in human capital development e.g. schooling. The second contribution is that we examine the potential for using rural labor markets as a mechanism to share agricultural surplus in the form of wage payments to household with excess labor – often landless and poor. The World Development Report 2008 (World Bank, 2008) contends that using rural labor markets as a pathway out of poverty is a challenge that "remains poorly understood and sorely neglected in policy making". Yet the rural labor force continues to grow at remarkable rates in most developing countries, especially those with an already high share of the world poor. In India, for example, the rural labor force continues to grow at about 1.5% annually, adding about 4 million people every year to the rural workforce (World Bank, 2008). In neighboring Bangladesh, about 1 million people join the rural workforce annually. Nearly 60% of rural households in Sub-Saharan Africa are employed in agriculture (World Bank, 2014).

Results from this study indicate that access to credit reduced demand for child labor and freed about 37 hours per acre of child labor. The average farmer in the sample cultivates 2.9 acres. Assuming 8 working hours a day, the impact translates to 13 working days of child labor freed which may then enable children to go to school. The results also show that group credit increased demand for adult hired labor. That group credit reduces demand for child labor and increases demand for hired labor suggests there is scope for increased mechanization and labor-substituting crop management practices. The positive impact in reduced child labor indicates that addressing market failures through group lending may lead to benefits in long-term capital development. A growing body of literature suggests that imperfections in markets for productive inputs could lead to dire consequences if they persist over time. For example, Ghatak and Jiang (2002) and Aghion and Bolton (1997) show that poorly functioning credit markets could over time lead to long-term consequences of persistent income inequality and low level of per-capita income in the economy.

We examine the impact of group credit on demand for hired adult labor and own child labor for maize production. Two estimation approaches are used. In section 3.3 we estimate linear approximations of the labor demand equation suggested by theory (section 2.2). For robustness checks we also estimated the average treatment effects (ATE) using approaches in the evaluation literature and theory (section 2.2). The results of from the two approaches are consistent. They show that group credit increased demand for adult hired labor and decreased demand for child labor. However, the magnitude of these effects differs depending on the method used. With regard to impact on adult hired labor, the factor demand estimations give an increase of 141.82 percent from pre-borrowing levels while the ATE gives an increase of 67.47 percent from pre-borrowing levels. With regard to impact on child labor, the factor demands estimations give a decrease 51.82 percent from pre-borrowing levels while the ATE gives a decrease of 65.32 percent from pre-borrowing levels. Both results suggest that farmers are more than substituting adult hired labor for child labor. The ATE results provide robustness checks for linear approximations of demand estimations and confirms the direction of impacts (positive impact on adult hired and negative on child labor) as well as that farmers are more than substituting adult labor for child labor. However, the ATE uses less information than linear approximations because the impact is measured through a participation dummy rather than loan amounts. We conclude that that group credit increased demand for adult hired labor by 141.82

percent from pre-borrowing levels and decreased demand for child labor 51.82 percent from pre-borrowing levels.

Figure 3.1: Per-capita Land access in Rural Kenya



3.2. Estimation Strategy

The impact of group credit on demand for adult hired labor and child labor will be estimated using the demand equations suggested by the theoretical model (section 2.2). The optimal factor demand were given in equation 2.3 thus:

$$x^*(p, w, K, C(A, S, T), G(M, N), E)$$

Where x^* is the profit maximizing choice of factors, including adult hired labor and child labor per unit land, K are inputs that do not vary with plot size e.g. skills and knowledge about farming, p is price of maize grain, w is price of factors such as seeds and fertilizers, C is conventional loans per unit land, G is group loan per unit land, and is E wealth. The amount a farmer could borrow from conventional sources C is limited by several factors, including land owned A, salaried income S, and fixed assets T. We write per-acre conventional credit as $C(A, S, T)$. On the other hand, the amount a farmer could borrow from group sources G is limited by a per-acre credit limit M that is exogenously imposed by the group, and the value of liquid household assets N required by groups as quasi-collateral. The per-acre group credit is written $G(M, N)$.

The production function underlying the above demand functions is estimated to be translog. This functional form was suggested by multi-step criteria for selecting the most suitable production function (see chapter 4). The criteria includes maintained hypothesis about parameters of the production function – in particular regarding yield response to seed, relative fitness of competing functional forms to available data, and plausibility of parameters over the input-output range. There are at least two challenges in empirically estimating the impact on labor demands: (i) input demand functions for the translog are highly non-linear and the structural parameters can be hard to estimate, and (ii) both demand for hired adult labor and child labor involve corner solutions because a significant proportion of households in the sample did not use these sources of labor.

The Tobit model will be used to represent labor demand equations (Wooldridge, 2001). An alternative to the Tobit model is the double hurdle model which assumes that the decision to hire labor or to use child labor is independent of the decision on how much amount of hired labor to hire or child labor to use. But these assumptions are unlikely in the study area and research question because: (i) these farmers have been cultivating maize season after season for many years, (ii) they would be knowing both the amount of labor per acre needed for various farm operations (planting, weeding etc.) and their endowment of adult family labor, (iii) they would rationally expect that the difference between labor needed and labor endowment would be met through hired labor or child labor, (iv) since farmers are price takers in input markets and factor prices are well known among farmers and hardly vary from season to season, farmers would be aware of the amount of man hours they could hire for any budget. Therefore, there isn't much to suggest that the decision to hire labor or to use child labor may be independent of the decision on how much amount of hired labor to hire or child labor to use. The empirical density for both labor types are given in figure 3.2 and the corner solutions are represented by a pile up at zero demands for labor. The density is continuous at positive labor demands. The linear approximation of labor demand equations is given by.

$$x_{ijlt}^{*} = \alpha_t + B_{iijt}\theta + K_{iijt}\beta + C_{ijlt}(.)\varphi + G_{ijlt}(.)\gamma + E_{iijt}\partial + F_j + F_l + F_i + \varepsilon_{it} \qquad (3.1a)$$

$$x_{ijlt} = max(0, x_{ijlt}^{*}) \qquad (3.1b)$$

where, subscript i, j, l, t respectively denote farmer, village, group, and season. B_{ijlt} is a vector of output and input prices comprising of maize grain prices at the time of purchasing inputs, price of fertilizers, and price of seed. The corresponding vector of parameters is given by θ. The production decision of any individual farmer does not determine market prices. Farmers are price takers in input and output markets and the vector B_{iljt} is exogenous. The vector K_{ijlt} accounts for skills and knowledge about farming. It is measured by level of education and age of the head of the household. These variables are not determined by decisions about agricultural production and therefore are expected to be exogenous. The variables F_j, F_l, and F_i represent village, group, and farm fixed effects respectively. ε_{it} is a disturbance term that follows

$\varepsilon_{it} \big| B_{ijlt}, K_{ijlt}, C_{ijlt}, G_{ijlt}, E_{iijt}, F_j, F_l, F_i \sim Normal\ (0, \sigma_{\varepsilon}^{2})$.

The village fixed effects capture attitudes towards child labor and family size that are distinctive to a village. These attitudes are shaped by unique characteristics of a village e.g. long-term access to basic education. Therefore, we can write a linear projection of F_j thus

$$F_j = \delta D_j + v_j \qquad (3.2)$$

where, D_j is a vector of village characteristics (such as age of the oldest elementary school and sum of elementary and secondary schools), and v_j is a normally distributed random disturbance term which is uncorrelated with D_j. Similarly, the group fixed effects are shaped by unique characteristics of a group e.g. initial group size, years since registration, and proportional turnover (sum of exit and entry as proportion of group size). A linear projection of group fixed effects is given by.

$$F_l = \omega G_l + v_l \qquad (3.3)$$

where, G_l is a vector of the group characteristics and v_l is a normally distributed random disturbance term which is uncorrelated with G_l.

Substituting equation (3.2) and (3.3) into equation (3.1a), we get the following estimating equation

$$x^*_{ijlt} = \alpha_t + B_{iijt}\theta + K_{iijt}\beta + C_{ijlt}\varphi + G_{ijlt}\gamma + E_{iijt}\partial + \delta D_j + \omega G_j + u_{it} \qquad (3.4a)$$

$$x_{ijlt} = max\left(0, x^*_{ijlt}\right) \qquad (3.4b)$$

Where $u_{it} = \varepsilon_{it} + v_j + v_l$ is a composite disturbance term that follows

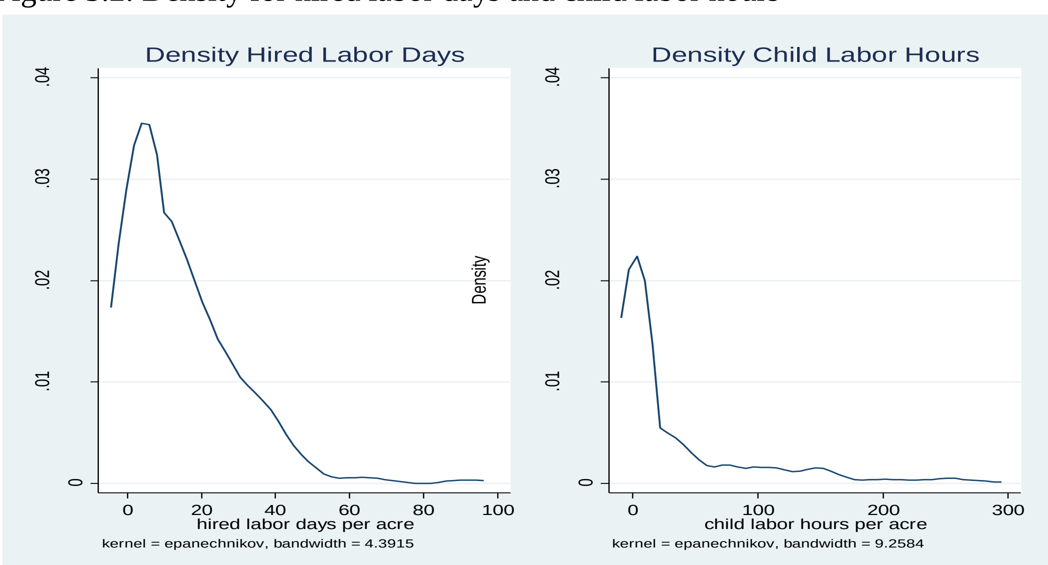
$u_{it}\big|B_{iijt}, K_{iijt}, C_{ijlt}, G_{ijlt}, E_{iijt}, P_{lt}, D_j, G_j \sim Normal\ (0, \sigma_u^2)$. Equation (3.4) is the Tobit estimating equation used for both labor demands.

The impact of group credit on demand for labor depends on the parameter γ. The amount of conventional loans C_{ijlt} and group loans G_{ijlt} is potentially endogenous for various reasons, including self-selection into borrowing from either source. To address the endogeneity problem we use instrumental variables in the Tobit regression – the Smith-Blundell approach (Smith and Blundell, 1986). The instruments for conventional loans C_{ijlt} are total landholding A_{ijlt} and value of fixed assets T_{ijlt}. And the instruments for group loans G_{ijlt} are the value of commonly found assets that are used as collateral in group borrowing arrangements N_{ijlt}. In the estimating equation we use salaried income dummy and informal income dummy to proxy for farmers wealth E_{iijt}.

3.3. Results for Demand Equations

The analysis draws from cross-sectional household survey data for the 2006 cropping season. The sample includes farmers in groups that were eligible and received credit in 2006 (treatment) and farmers in groups that were ineligible and did not receive credit in 2006 (control). The density of days of adult hired labor per-acre and child labor per-acre for pooled data is provided in figure 3.2 below.

Figure 3.2: Density for hired labor days and child labor hours



The results for impact of group loans on demand for adult hired labor child labor are presented in table 3.1. The dependent variables are days of adult hired labor per acre (column 2) and days of child labor per care (column 3). The explanatory variables are conventional loans, group loan, price of maize at planting, price of fertilizers, wage rate, land preparation cost per acre, seed cost per kilogram, household size, distance to seller of fertilizers, distance to the market, distance to motorable road, informal income dummy, salaried income dummy, age of household age, squared age of household head, education of household head, female headed households dummy, age of oldest primary school in the village, number of primary schools in the village, age of group since registration, proportional turnover in the group – sum of exit and entry as a proportion of initial group size.

Conventional loans and group loan are potentially endogenous. This problem is addressed by using the instrumental variables approach. The instrumental for conventional loans is total landholding and value of assets. The instrument for group loan is value of assets provided as security to the group. The equations are estimated using maximum likelihood estimator in STATA – the *ivtobit* command. The coefficients of Tobit regressions only give us the direction of effects on labor demands, but not their average partial effects (Wooldridge, 2001). We calculate marginal effects at the means of explanatory variables and report them in table 3.1.

The results show that group credit increased demand for adult hired labor. An increase of group loans by one Kenya Shillings (KES) made farmers hire about 0.0014 days of adult labor per-acre. The result is statistically significant at 10% and therefore we reject the null hypothesis of zero impacts on adult hired labor. The pre-borrowing average labor demand was 11.07 days per acre and average maize cultivation 2.43 acres. The average group loan size is KES 11,215.69 per acre. Therefore, an average farmer receiving group credit increased demand for adult hired labor by 15.70 days per acre (0.0014*11,215.69). We conclude that group credit increased demand for adult hired labor by 141.82 percent from pre-borrowing levels.

The procedure used to estimate the impact on demand for child labor is similar to what we followed for impact on adult hired labor. The dependent variable is days of child labor per acre. And the explanatory variables are exactly the same as in the adult hired labor equation. The results are presented in second column of table 3.1. The results show that group credit reduced demand for child labor. An increase of group loans by one KES made farmers reduce child labor by about 0.0022 days of child labor per-acre. The result is statistically significant at 10% and therefore we reject the null hypothesis of zero impacts on child labor. The pre-borrowing average child labor demand was 47.61 days per acre and average maize cultivation 2.43 acres. The average group loan size is KES 11,215.69 per acre. Therefore, an average farmer receiving group credit decreased demand for child labor by 24.67 days per acre (0.0022*11,215.69). We conclude that group credit decreased demand for child labor 51.82 percent from pre-borrowing levels.

The result that group credit increased demand for adult hired labor and decreased demand for child labor appears to suggest substitution effects that allow children to spend more time away from farm work and possibly in school. The marginal productivity of labor is remarkably low (see chapter 4 section 4.4). Therefore it is likely farmers may also be shifting to more productive but capital intensive inputs e.g. mechanized land preparation (instead of manual tillage) and herbicides (instead of manual weeding). Nevertheless the significant impact on demand for adult hired labor suggests that increased agricultural credit can provide a mechanism for distributing agricultural surplus to land constrained but labor abundant households while keeping children away from working in farms. The latter would allow for children to attend school which promotes long-term human development.

The result that credit frees child time out of labor confirms that innovations in financial markets are likely to have long-term effects on human capital development, and therefore should not be evaluated only on the basis of short-term outcomes. Moreover, this result reinforces the importance of first-best mechanisms to address credit market failures in developing countries. Often times, the critical failure in rural credit market is due to information asymmetries between borrowers and commercial lenders, even though this information is available locally between neighbors who often know each other's credit history and historical returns from farming. Group credit programs thrive on their ability to draw on this information, thus providing a first-best intervention.

According to the results in table 3.1 conventional loans appear to have no impact on demand for adult hired labor and child labor. Consistent with economic theory the wage rate has a negative relationship with demand for adult hired labor but insignificant effects on demand for child labor. Household size is negatively associated with both labor demands. Having informal income or salaried income is also negatively associated with labor demands. Similarly, the education levels of household head shows a negative relationship with demand for adult hired labor as well as demand for child labor but age of household head is positive associated with both labor demands. The more primary schools there are in the village the less is demand for hired labor and child labor.

Table 3.1: Estimates of impact on adult hired labor and child labor

Variable	Adult hired labor	Child labor
Conventional loans	0.00	-0.00
	(1.11)	(0.49)
Group loans	0.00146	-0.00225
	(1.67)+	(1.73)+
Maize price at planting	-2.2523e-03	-1.0154e-02
	(0.44)	(0.46)
Fertilizer price	0.1961	0.2782
	(0.36)	(0.15)
Wage rate	-0.0955	0.1608
	(1.00)	(0.51)
Seed cost	-0.0051	0.5161
	(0.04)	(1.31)
Household size	-4.0424	-3.1749
	(1.35)	(0.31)
Distance to fertilizer seller	-0.1758	-1.0041
	(0.61)	(1.04)
Distance to market	-0.1322	2.5208
	(0.07)	(0.39)
Distance to motorable road	-11.0026	32.8381
	(0.99)	(0.91)
Informal income dummy	-4.5759	8.3797
	(0.59)	(0.32)
Salaried income dummy	0.7213	-56.6772
	(0.08)	(1.93)+
Age of head	0.6074	23.6113
	(0.38)	(4.09)**
Age of head squared	-0.0059	-0.2304
	(0.35)	(3.92)**
Education of head	-0.0215	-0.8600
	(0.03)	(0.41)
Female head dummy	-0.4815	-86.2831
	(0.06)	(3.01)**
Age of oldest primary school	0.3016	0.1211
	(1.24)	(0.15)
Number of primary schools	-9.8915	-6.2499
	(1.29)	(0.23)
Group size at registration	1.0369	1.8046
	(1.06)	(0.53)
Age of group	-1.4399	2.0429
	(1.48)	(0.61)
Proportional turnover	3.1892	-17.7550
	(0.61)	(1.02)
Constant	-20.0618	-601.3197
	(0.35)	(2.99)**
N	206	206

The significance levels are: + $p<0.1$; * $p<0.05$; ** $p<0.01$, Z statistic in parenthesis

3.4. Average Treatment Effects

The estimations rely on cross-section data which rules out the double differencing method that was used to estimate impact on fertilizers, hybrid seeds, and land in chapter two above. The data available is for only one cropping season where some households received loans through the credit program and others did not. Therefore, this paper employs Propensity Score Matching (PSM) to construct a counterfactual for borrowing households from the sample of non-borrowing households (Rosenbaum and Rubin, 1983; 1985). We drop the subscripts $j, l, and\ t$ to reduce notational clutter. To motivate PSM let $\tilde{x}_{il}$ represent labor demand for farmer i. Participation in the group credit program can take two values: $P_{glt} = 1$ for farmers receiving credit and $P_{glt} = 0$ for farmers that did not receive credit. When farmer i participates the conditional labor demand is $\tilde{x}_{i1}$. And when farmer i does not participate the conditional labor demand is is $\tilde{x}_{i0}$. The Average Treatment Effect (ATE) of group credit on labor is labor demand when the farmer participates minus labor demand when the farmer does not participate, that is

$$ATE = E(\tilde{x}_{i1}|P_{gll} = 1) - E(\tilde{x}_{i0}|P_{glt} = 1) \qquad (3.5)$$

The cross-sectional data provides $E(\tilde{x}_{i1}|P_{glt} = 1)$ from the sample of borrowing households. But once we observe $E(\tilde{x}_{i1}|P_{glt} = 1)$ we cannot observe $E(\tilde{x}_{i0}|P_{glt} = 1)$ because the farmer cannot be in both the borrowing and non-borrowing state in the same cropping season. $E(\tilde{x}_{i0}|P_{glt} = 1)$ is the missing counterfactual that we need to construct from labor demands of non-borrowing farmers which is denoted $E(\tilde{x}_{i0}|P_{glt} = 0)$. It does not suffice to simply replace the missing counterfactual of borrowing farmers $E(\tilde{x}_{i0}|P_{glt} = 1)$ with labor demands of non-borrowing farmers in equation (3.5) as that would most likely lead to biased estimate of ATE. The bias is likely because there is nothing to suggest that non-borrowers are a true counterfactual for borrowers. The bias is given by

$$B = E\left(\tilde{x}_{i0} \middle| P_{glt} = 1\right) - E\left(\tilde{x}_{i0} \middle| P_{glt} = 0\right) \quad 3.6$$

In summary PSM calculates the probability of participating (propensity score) between borrowers and non-borrowers. The propensity score is used to identify a matched sub-sample of farmers in the region of common support and data from matched farmers (treatment and control) is used to estimate impacts. The matched sub-sample approximates a sample that would have been obtained with random assignment of treatment and control. The score is calculated by regressing P_{glt} on all variables in the labor demand equation, including the vectors B_{iijt} and K_{iijt}. The estimating equation for labor demands is given by the following Tobit model.

$$x^*_{ijlt} = \alpha_t + B_{iijt}\theta + K_{iijt}\beta + P_{ict}\varphi + P_{glt}\gamma + F_j + F_l + \varepsilon_{it} \quad (3.7a)$$

$$x_{ijlt} = max\left(0, x^*_{ijlt}\right) \quad (3.7b)$$

3.5. Results for Average Treatment Effects

The analysis draws from cross-sectional household survey data for the 2006 cropping season. The sample includes farmers in groups that were eligible and received credit in 2006 (treatment) and farmers in groups were ineligible and did not receive credit received in 2006 (control). The treatment was not randomly assigned and therefore there is selection bias. The problem of selection bias is addressed using Propensity Score Matching (PSM). Estimation proceeds in two stages. First we estimate a Probit equation where the dependent variable is treatment into the program. The results are provided in table 3.3 below. The results of the Probit model are used to calculate the propensity score and identify treatment and control farmers that are similar. Only data from farmers that are identified to be similar and in the region of common support will be used for further analysis to allow for precise estimates of the average treatment effects (Heckman et.al, 1997). Table 3.2 gives the distribution of the sample of treatment and control in the region of common support.

Table 3.2: Distribution of the sample in the region of common support

Region of common support = estimated propensity score [.053, .929]	Control	Treatment	Total
.053	57	10	67
.2	93	40	133
.4	49	47	96
.6	11	22	33
.8	1	7	8
Total	211	126	337

The results of the Probit model (table 3.3) shows that the propensity to participate in the group credit program is influenced by both household and group characteristics. Household size and education of head are positively associated with group borrowing while the incidence of having salaried income and female head of household decreases the propensity to be involved in group borrowing. The results show that the most important determinants of participation in group borrowing are the characteristics of a group and the village. Of these the most significant factor is the number of years a group has existed since registration. In chapter 1 section 1.3 we learnt that under the group borrowing rules only groups that have been registered with the federation for more than two years could participate. The results are consistent with these rules. Group membership at registration is negatively associated with borrowing and so is the age of the oldest primary school in the village.

The second step is to estimate Tobit models using data from farmers in the region of common support. The coefficients of Tobit regressions only give us the direction of effects on labor demands, but not their average partial effects (Wooldridge, 2001). We calculate marginal effects at the means of explanatory variables and report them in table 3.4. The dependent variables are days of adult hired labor per acre (column 2) and days of child labor per care (column 3). The explanatory variables are conventional loans, group loan, price of maize at planting, price of fertilizers, wage rate, land preparation cost per acre, seed cost per kilogram, household size, distance to seller of fertilizers, distance to the market, distance to motorable road, informal income dummy, salaried income dummy, age of household age, squared age of household head, education of household head, female headed households dummy, age of oldest primary school in the village, number of primary schools in the village, age of group since registration, proportional turnover in the group – sum of exit and entry as a proportion of initial group size.

The results show that group credit increased demand for adult hired labor. The average treatment effect (ATE) of group credit on demand for adult hired labor is 7.47 days per acre. The result is statistically significant at 5% and therefore we reject the null hypothesis of zero impacts on adult hired labor. The pre-borrowing average labor demand was 11.07 days per acre and average maize cultivation 2.43 acres. The average group loan size is KES 11,215.69 per acre. Therefore, an average farmer receiving group credit increased demand for adult hired labor by 67.47 percent from pre-borrowing levels.

The procedure used to estimate the impact on demand for child labor is similar to what we followed for impact on adult hired labor. The dependent variable is days of child labor per acre. And the explanatory variables are exactly the same as in the adult hired labor equation. The results are presented in the second column of table 3.4. The results show that group credit reduced demand for child labor. The average treatment effect (ATE) of group credit on demand for child labor is -31.10 days per acre. The result is statistically significant at 10% and therefore we reject the null hypothesis of zero impacts on adult hired labor. The pre-borrowing average labor demand was 47.61 days per acre and average maize cultivation 2.43 acres. The average group loan size is KES 11,215.69 per acre. Therefore, an average farmer receiving group credit decreased demand for child labor by 65.32 percent from pre-borrowing levels.

According to the results in table 3.4 conventional loans have similar impact to group loans – positive impact on demand for adult hired labor and negative impact on child labor. Consistent with economic theory the wage rate has a negative relationship with demand for adult hired labor but insignificant effects on demand for child labor. Household size is negatively associated with demand for child labor. Having informal income or salaried income is also negatively associated with labor demands. The education level of household head appears to be positively correlated with demand for adult hired labor but has insignificant effects demand for child labor. Age of household head is positive associated with both demand for child labor. The more primary schools there are in the village the less is demand for hired labor and child labor.

Table 3.3: Probit model of propensity to borrow from the group program

Variable	Treatment dummy
Household size	0.125
	(2.32)*
Distance to fertilizer seller	-0.0004
	(0.04)
Distance to market	0.1113
	(1.59)
Distance to motorable road	-0.1447
	(0.62)
Informal income dummy	0.0317
	(0.19)
Salaried income dummy	-0.6179
	(3.43)**
Age of head	-0.0125
	(0.29)
Age of head squared	0.0001
	(0.27)
Education of head	0.0299
	(1.72)+
Female head dummy	-0.5317
	(2.06)*
Age of oldest primary school	-0.0230
	(3.11)*
Number of primary schools	-0.0155
	(0.10)
Group size at registration	-0.0314
	(1.82)+
Group age	0.0858
	(3.35)
Proportional turnover	0.0486
	(0.31)
Conventional loans	-5.87e-06
	(1.67)+
Value of assets	0.0001
	(3.41)**
Constant	0.4249
	(0.39)
Log likelihood	-194.719
N	344

The significance levels are: + $p<0.1$; * $p<0.05$; ** $p<0.01$, Z statistic in parenthesis

Table 3.4: Factor demand estimates of impact on adult hired labor and child labor

Variable	Adult hired labor	Child labor
Treatment dummy	7.47	-31.10
	(3.45)**	(1.94)+
Maize price at planting	-0.00264	-0.01416
	(0.85)	(0.52)
Fertilizer price	8.9316e-03	1.4137e+00
	(0.04)	(0.81)
Wage rate	-0.0435	0.3982
	(0.99)	(1.23)
Seed cost	-0.0128	0.3695
	2.62)**	(1.18)
Household size	0.4329	-6.9035
	(0.61)	(1.30)
Distance to fertilizer seller	-0.1334	0.1596
	(1.02)	(0.17)
Distance to market	0.0967	3.5917
	(0.12)	(0.56)
Distance to motorable road	-8.1954	32.1811
	(2.43)*	(1.41)
Informal income dummy	1.3642	-1.2265
	(0.60)	(0.08)
Salaried income dummy	-0.5049	-19.2388
	(0.21)	(1.11)
Age of head	-0.4550	25.9902
	(0.83)	(5.44)**
Age of head squared	0.0041	-0.2425
	(0.76)	(5.15)**
Education of head	0.6335	-1.1556
	(2.81)**	(0.70)
Female head dummy	-2.3205	-64.7923
	(0.68)	(2.49)*
Age of oldest primary school	0.2782	0.0586
	(2.83)**	(0.08)
Number of primary schools	-7.6785	8.1561
	(3.71)**	(0.55)
Group size at registration	0.2235	1.5970
	(1.02)	(1.00)
Group age	-0.2499	1.1291
	(0.77)	(0.46)
Proportional turnover	0.3919	-0.4892
	(0.19)	(0.03)
Conventional loans	0.0001	-0.0012
	(4.35)**	(2.22)*
Value of assets	0.0001	-0.0003
	(3.41)**	(1.93)+
Constant	13.4885	-746.8156
	(0.77)	(5.11)**
N	334	335

The significance levels are: + $p<0.1$; * $p<0.05$; ** $p<0.01$, Z statistic in parenthesis

3.6. Conclusions

In this chapter we have examined the impact of group credit on demand for hired adult labor and own child labor for maize production. Two estimation approaches have been used. In section 3.3 we estimated equations of labor demand. For robustness checks we also estimated the average treatment effects (ATE) using approaches in the evaluation literature and theory (section 2.2). The results of two approaches are qualitatively consistent and lead to the same conclusions. They show that group credit increased demand for adult hired labor and decreased demand for child labor. However the magnitude of these effects differs. With regard to impact on adult hired labor, the factor demand estimations give an increase of 141.82 percent from pre-borrowing levels while the ATE gives an increase of 67.47 percent from pre-borrowing levels. With regard to impact on child labor, the factor demand estimations give a decrease 51.82 percent from pre-borrowing levels while the ATE gives a decrease of 65.32 percent from pre-borrowing levels. The implication of these results is that the reduction in child labor is more than substituted by increased demand for adult hired labor. The ATE results provide robustness checks for factor demand estimations. While the ATE is useful in providing robustness checks the estimator uses less data in the sense that participation of group credit is reduced to a dummy rather than loan amounts. We conclude that that group credit increased demand for adult hired labor by 141.82 percent from pre-borrowing levels and decreased demand for child labor 51.82 percent from pre-borrowing levels.

This work makes two main contributions. There has been growing interest in understanding the relationship between credit constraints and decisions about human capital acquisition, but most studies have examined the effects of negative income shocks on the choice between sending children to school and diverting their time towards labor. The main contribution of this paper is that we examine whether a positive innovation in credit could free child time to investments in human capital development. The result that credit frees child time out of labor confirms that innovations in financial markets are likely to have long-term effects on human capital development, and therefore should not be evaluated only on the basis of short-term outcomes. Moreover, this result reinforces the importance of first-best mechanisms to address credit market failures in developing countries. Often times, the critical failure in rural credit market is due to information asymmetries between borrowers and commercial lenders, even though this information is available locally between neighbors who often know each other's credit history and historical returns from farming. Group credit programs thrive on their ability to draw on this information, thus providing a first-best intervention.

The second contribution of this paper is that examining the impact of group credit on hired labor provides a better understanding of the potential of rural wage labor markets to provide a mechanism for sharing agricultural surplus to poor landless households. The result that group credit increased demand for adult hired labor suggests rural labor markets can provide agricultural jobs for land constrained but labor abundant rural households – while keeping children away from working in farms. This is an important finding because using rural labor markets as a pathway out of poverty is a challenge that "remains poorly understood and sorely neglected in policy making" – *The World Development Report 2008* (World Bank, 2008). Yet the rural labor force continues to grow at remarkable rates in most developing countries, especially those with an already high share of the world poor.

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CHAPTER FOUR: THE IMPACT OF GROUP CREDIT ON MAIZE OUTPUT AND PROFITS

4.1. Introduction

This chapter estimates the impact of group credit on maize output and profits. A stochastic production frontier model will be used to estimate marginal products of inputs and to explicitly account for possible technical inefficiency in maize production. Technical inefficiency refers to the gap between actual output realized by farmers and the frontier of a production technology. Gains in technical efficiency would increase output levels. Examples of sources of technical efficiency may include better timing of farm operations such as planting, irrigation, fertilizer application, and weeding. Better timing of these farm operations may improve actual output and narrow the gap with the frontier. In this study we hypothesize that improved working capital due to group credit and conventional loans may enable farmers to conduct farm operations in a timely manner which in turn may lead to improved technical efficiency.

Stochastic frontier models were first introduced in Aigner, Lovell et al., (1977) and Meeusen and van Den Broeck, (1977) and have since been used to study both farm production and non-farm production. Assuming a linear relationship the unobserved production frontier may be written;

$$y_i^* = x_i\emptyset + v_i \qquad (4.1)$$

Where, y_i^* is the unobserved frontier for per acre maize output on plots $i = 1,2,3..N$, x_i is a vector of per acre application rates for inputs such as seeds, nitrogen, phosphorous, potassium, seeds and labor; $\emptyset$ is a vector of parameters, and v_i is a disturbance term distributed as $N(0, \sigma_v^2)$. Actual output per acre (denoted y_i) differs from the frontier by a one-sided inefficiency term u_i

whose distribution depends on a vector of exogenous variables z_i. The stochastic frontier model is given as;

$$y_i = x_i\emptyset + v_i - u_i(z_i, \delta),\ u_i(z_i, \delta) \geq 0, \quad (4.2)$$

The terms u_i and v_i are assumed independent of each other and v_i is also independent of both x_i and z_i. The distribution of u_i conditional on z_i is independent of x_i. Parameters of the inefficiency term are given by the vector δ.

4.2. Estimation Strategy for Stochastic Production Frontier Model

4.2.1. Production Function

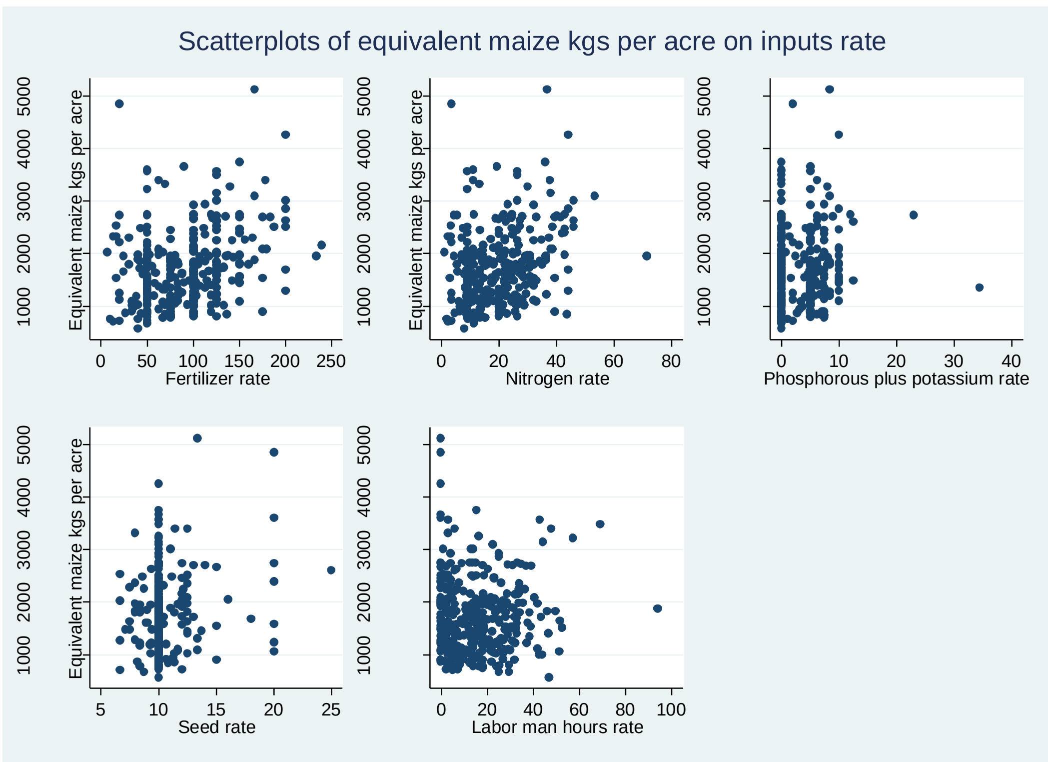
The literature suggests many alternative functional forms for estimating the frontier part of the stochastic frontier model. Potential candidates include Quadratic, Cubic, Translog, Transcedental, Mitscherlich, Spillman, Cobb-Douglas, Leontief, Generalized Power, Constant Elasticity of Substitution etc. These functional forms provide a rich menu to choose from. But the task of selecting one from competing alternatives is non-trivial because it is difficult to know the true functional form for agricultural production relationships. When the true functional form is unknown one must develop criteria to choose the most suitable form for a particular analysis (Griffin, Montgomery, and Rister, 1987). Elements of a criteria for selecting a functional form may include maintained hypothesis regarding parameters of a production relationship, properties of available data, or relative fitness of competing functional forms to available data (Griffin, Montgomery, and Rister, 1987). This study follows a three step criteria to select a suitable function form.

The first consideration in the criteria is maintained hypothesis about yield response to seed. The maintained hypothesis is that planting maize seed without using other inputs (fertilizer and labor) could result in some harvest, although the expected yield is much lower compared to when fertilizers and labor are used. Several functional forms are eliminated because they contradict this maintained hypothesis. The second consideration is fitness of data. The third and final step is to select the functional form that gives plausible marginal productivity of inputs over the range of input data. These hypothesis were formulated based on information obtained through interviews with farmers in high potential zones of Kenya over the course of several years. During the interviews I found cases where farmers planted maize seed without fertilizers and without much effort in crop management. Expected yields on such plots were minimal but nevertheless non-zero.

The maintained hypothesis rules out several functional forms, such as Cobb-Douglas, Leontief, Mitscherlich, Spillman, Transcendental, and Generalized Power functions. The hypothesis is satisfied by the following functional forms; linear, quadratic, cubic, resistance, generalized cox-box, and augmented fourier. Among those satisfying the hypothesis the quadratic and cubic are perhaps the most commonly used functional forms. The maintained hypothesis that non-zero output is possible even when a farmer fails to apply some of the inputs is neither satisfied nor unsatisfied in the Translog production function (Griffin, Montgomery, and Rister, 1987). Nevertheless, the Translog is considered a candidate because of its wide use in estimating production relationships.

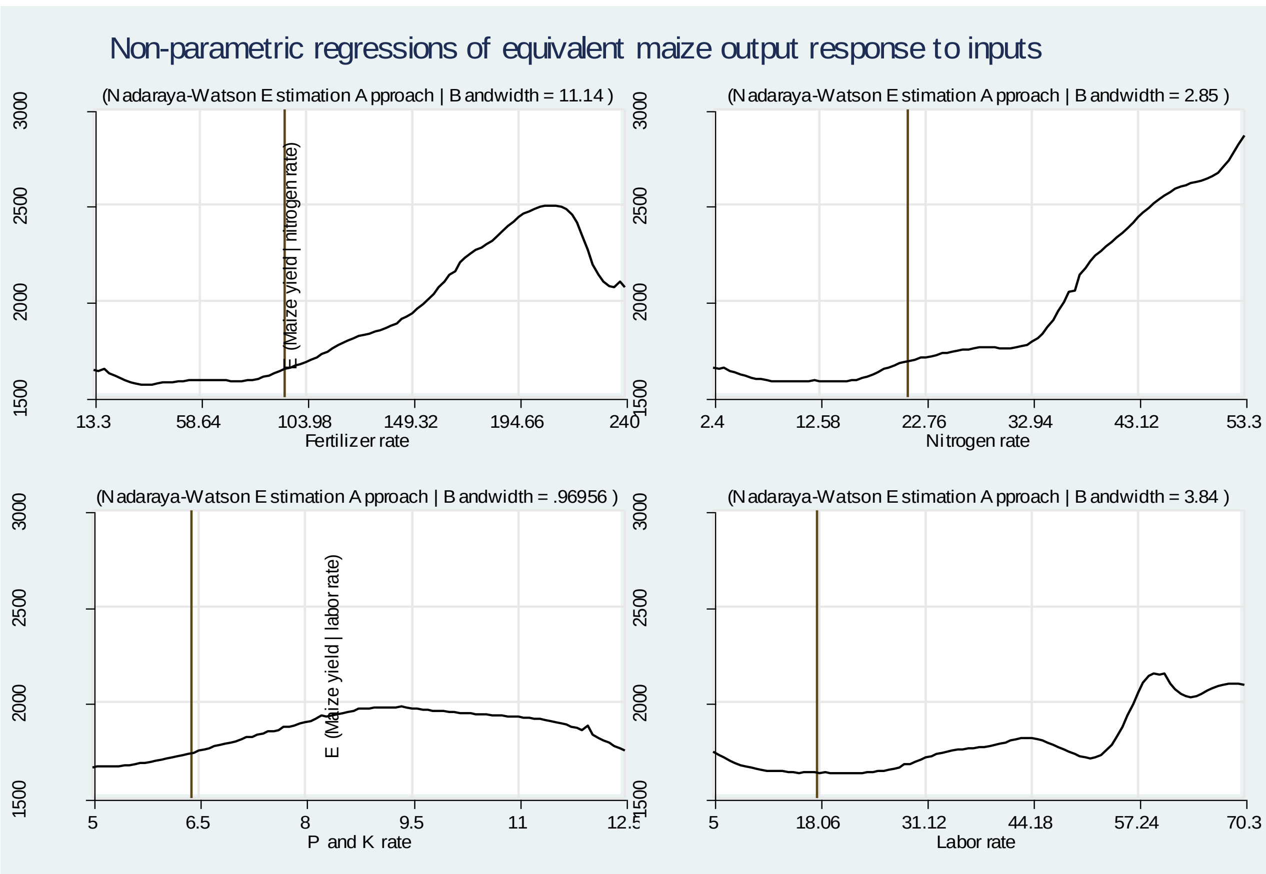
The second criterion of fitness to data is applied by examining the empirical distributions of inputs and maize yields, as well as non-parametric estimates of yield response to seeds, fertilizers, nutrients in fertilizers, and labor. We begin by examining scatterplots of the inputs against maize yield (see figure 4.1 below). The scatterplot for fertilizers show application rates are concentrated around the following rates – 50, 75, 100, 125, and 150 kilos per acre. For each of these concentration points there is considerable variation in yields. The application rate of nitrogen nutrient appears relatively more scattered and with more variation in yields compared to when fertilizer is taken as aggregate of all nutrients (commodity fertilizer). Phosphorous and potassium nutrients are applied at fixed ratios (see figure 4.3 below) and their individual and combined application rates are much lower than nitrogen. Therefore, phosphorous and potassium nutrients are analyzed together. We find a concentration around zero and the rest of the observations are dispersed below 10 kilograms per acre. The distribution of seed rate is centered around 10 kilos per acre and maize yields vary considerably around that point in the distribution.

Figure 4.1: Scatter-plot of maize yields against inputs



The third step in assessing goodness of fit is to compute non-parametric estimates of yield response to inputs. These non-parametric estimates provide a regression curve that is free from any assumption about functional forms. The shape of the curve could be used to assess if data rules out any of the candidates – translog, linear, quadratic, and cubic. The regression curves are estimated using the Nadaraya-Watson estimator (Nadaraya, 1964; Watson 1964) with optimal bandwidth parameter generated from the data (see Appendix 4.1 for more details on estimation procedures). Figure 4.2 below provides the non-parametric yield response curves for fertilizer commodity, nitrogen nutrient, phosphorous and potassium nutrients combined, and labor. Seed is excluded because its response curve is hard to generate since many observations are piled up in the mean of the seed-rate distribution such that there are not sufficient observations to compute expected yield outside of mean seed rate.

Figure 4.2: Non-parametric estimates of maize yield response to inputs



The non-parametric regression of the response of per acre maize output to inputs rules out a linear function but does not rule out translog, quadratic, and cubic. However, it's important to remember the Nadaraya-Watson estimator is weak at both ends of the distribution because there are not many observations to calculate the conditional expectation of yields to inputs. Therefore, the shape of the regression curve at the ends should be interpreted with caution. Figure 4.2 suggests that the yield response to fertilizer increases in a decreasing rate and reaches peak at about 207 kilos per acre and then declines. Unlike fertilizer commodity, the per acre maize output response to nitrogen nutrient appears to be increasing throughout the range of data, while for phosphorous and potassium combined it increases until about 9 kilos per acre and then declines. The maize output response to labor increases at a decreasing rate reaching a maximum response at about 60 man hours per acre and then declines. The vertical line in each graph shows mean nutrient application rate. At mean application rates for all inputs the yield response is increasing which suggests the average farmer may increase outputs by using more inputs.

The data appears not to rule out any of the candidates – except linear – so the study will proceed to estimate the production part of the stochastic frontier model with the cubic production function (which nests quadratic) as well as the translog production function. The functional form that gives the most plausible marginal productivity of inputs over the range of input data will be selected as the final model. The cubic production function is written;

$$y_i = \emptyset_0 + \sum_{j=1}^{4} \emptyset_j x_{ij} + \sum_{j=1}^{4} \sum_{k=1}^{4} \emptyset_{jk} x_{ij} x_{ik} + \sum_{j=1}^{4} \sum_{k=1}^{4} \sum_{l=1}^{4} \emptyset_{jkl} x_{ij} x_{ik} x_{il} + e_i \quad (4.3)$$

Where, y_i is an index of per acre maize output in intercropped maize plots – that is $\sum_c y_{ic} p_c / p_1$ such that p_c is price of intercrops with crop 1 being maize, x_{i1} is nitrogen rate, x_{i2} is phosphorous and potassium rate, x_{i3} is seed rate, and x_{i4} is labor rate witrh all inputs measured on a per acre basis. The translog production funtion is written as;

$$lny_i = \emptyset_0 + \sum_{j=1}^{4} \emptyset_j \, lnx_{ij} + {}^1\!/_2 \left(\sum_{j=1}^{4} \sum_{k=1}^{4} \emptyset_{jk} lnx_{ij} lnx_{ik} \right) + \varepsilon_i \quad (4.4)$$

Maize yield and inputs are expressed in natural logs. In particular, y_i is the natural log of an index of per acre maize output in intercropped maize plots, x_{i1} is natural log of nitrogen rate, x_{i2}

is natural log of phosphorous and potassium rate, x_{i3} is natural log of seed rate, and x_{i4} is natural log of labor rate.

4.2.2. Technical Inefficiency

The original stochastic frontier model assumed that the inefficiency term u_i follows an identical and independent half-normal distribution. This assumption has since been relaxed in subsequent studies to allow for more flexibility – see Kumbhakar and Lovell (2000) for a detailed presentation of frontier analysis. Alvarez et al. (2006) present six distinct models with varying specifications for the inefficiency term based on either half-normal or exponential distributions. The specifications outlined in (Alvarez et al., 2006) were estimated in Liu and Myers (2008) using data on maize production from 8 agro-ecological zones in Kenya. They find that parameters of the production frontier (the primary interest of this work) hardly change and are robust to varying specification of the inefficiency term. Caudill et al. (1995) found similar results. This would suggest either half-normal or exponential distributions may be used to specify the inefficiency term in equation 4.2.

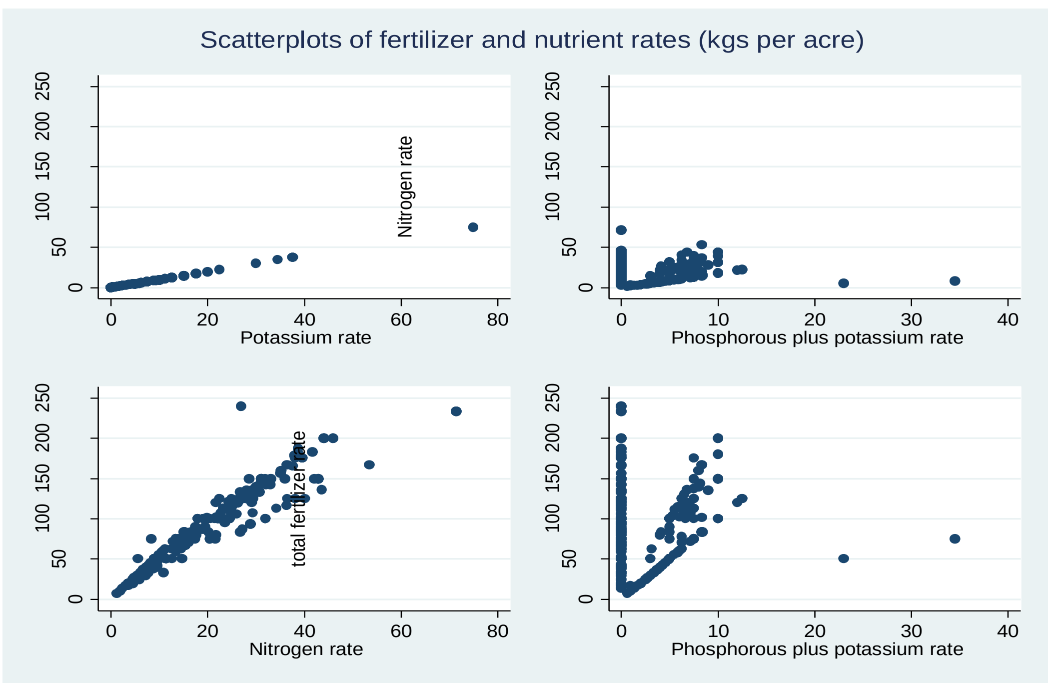
The exogenous variables used in the inefficiency term account for access to markets, human capital, use of tractor in land preparation, land tenure, and access to working capital. In rainfed agriculture, access to markets – as measured in this case by distance to fertilizer seller – would allow a farmer to buy fertilizer promptly when it rains thus improving timing of planting. Similarly, a farmer with access to a tractor would be able to prepare land in a timely manner compared to those using hand tools. For the level of human capital we use highest level of education among resident adults, age of household head, and gender of the household head. There is evidence that education may affect household decision making regarding farm operations leading to a positive effect on farm efficiency (Lockheed, Jamison, and Lau, 1980).

The inclusion of land tenure to capture possible differences in technical efficiency between plots owned by the household and those rented is motivated by previous studies that found positive relationship between secure tenure and farm productivity – for example Place and Hazell (1993) and Chand and Yala (2009). Other variables included in the inefficiency term are a dummy for monocrop plots and amounts borrowed through group credit and conventional loans. In monocrop plots a famer would be able to use farm implements to perform operations such as weeding and planting (if maize is not planted first). But this may not be possible in intercropped fields because maize is normally intercropped with beans in the study area.

4.3. Data

The data used to estimate marginal productivity of inputs is an index of per acre maize output and input use data for the 2006 cropping season. (For a detailed description of the data see chapter I). Fertilizer is measured as quantity of nutrients applied to a plot, that is nitrogen and phosphorous plus potassium combined. The data suggests that nitrogen is the most demanded by farmers relative to phosphorous and potassium (see figure 4.3). However, phosphorous and potassium may contribute to plant growth, health, and crop yields. Therefore, these nutrients are accounted for in the stochastic production frontier model, unlike other studies that use nitrogen alone (e.g. Marenya and Barrett, 2009). The scatterplot of nitrogen against total fertilizer indicates most of the observations fall closely along the 45 degree line at lower levels of fertilizer use, which suggests that the proportion of nitrogen in fertilizers is only similar on plots where fertilizer use was very low. However, the proportion of nitrogen varies as fertilizer use increases. In particular, the dispersion around the 45 degree line seems to widen with increased fertilizer use. The scatterplot of phosphorous and potassium suggests these nutrients are used in fixed proportions across different plots, which may cause multicollinearity in estimations. Therefore, we add phosphorous and potassium together and treat these nutrients as one to avoid multicollinearity and omitted data bias. The scatterplot for nitrogen against phosphorous and potassium indicates there are many plots where farmers use nitrogen (across the range of nitrogen application rates) without phosphorous or potassium. This suggests imbalanced fertilizer use that may be profitable short-term but fraught with long-term adverse consequences on soil health and crop productivity. In contrast, there is also a clear pattern of scatterplots along the 45 degree line, which appears consistent with balanced use of nitrogen and other nutrients for better management of soil fertility.

Figure 4.3: Scatter plot of nutrients utilization



4.4. Results of Stochastic Frontier Model

We estimate the stochastic frontier model in equation 4.2 using Maximum Likelihood Estimation (MLE). The two functional forms considered for the frontier part of the model are cubic and translog. For each functional form we estimate the model using half-normal and exponential distributions for the inefficiency term. For the translog function the likelihood function converges with the half-normal specification but does not converge with the exponential specification. For the cubic function, the likelihood function does not converge with the half-normal distribution and with the exponential distribution it fails to find feasible initial values. For these reasons we discuss only results of the translog function with half-normal specification for the inefficiency term because there was no convergence of the likelihood function in other models.

Both group credit and conventional loans are possibly endogenous variables in the inefficiency term. As described in the theoretical framework in chapter two, the amount of group credit a farmer could borrow is limited by a per-acre credit limit M that is exogenously imposed by the group and the value of liquid household assets N required by groups as quasi-collateral. On the other hand, the amount a farmer could borrow from conventional sources C is limited by several factors, including land owned A, salaried income S, and fixed assets T. These variables are used to instrument for group credit and conventional loans in a first step regression which also includes other exogenous variables in the inefficiency term. The results of first stage regressions are presented in annex table A4.1 and A4.2 respectively for group credit and conventional loans equations. Predicted values for group credit and conventional loans are then substituted into the stochastic frontier equation 4.2 which is then estimated using MLE.

The results of the translog production function are presented in table 4.1. The data for per acre maize output and inputs is in logs. Based on parameter estimates we calculated elasticities at the mean of logs. The mean logs of nitrogen, phosphorous and potassium, seeds, and labor are: 2.97, 3.26, 2.33, and 2.60 respectively. Using the estimation results in table 4.1 – with the half-normal specification of the inefficiency term – the estimated elasticity of maize yield to inputs are: 0.18 for nitrogen, 0.06 for phosphorous and potassium, -0.3 for seed, and 0.04 for labor. The estimates of elasticity are used to recover marginal productivity for each input at the mean. The estimated marginal products are 14.81 for nitrogen, 31.81 for phosphorous and potassium, -49.70 for seed, and 3.89 for labor.

That seed has negative marginal productivity is rather surprising. However, when we look at the distribution of seed rate it becomes clear that most observations are right at the mean and there is little variation – see the scatterplot for seed on figure 4.1. Furthermore, it was not possible to generate the non-parametric yield response curve of maize output to seed (see figure 4.2 for other inputs) since most observations on seed rate are piled up at the mean of seed-rate distribution such that there were not sufficient observations to compute expected yield outside of mean seed rate. Given this characteristic of the data it is plausible that any seed rate above the mean leads to diminishing maize output.

Next we test the hypothesis that the inefficiency term is equal to zero. The null of technical efficiency is rejected which indicates farmers are not technically efficient. There appears to be no relationship between access to group credit or conventional loans with technical efficiency. Education is negatively correlated with technical inefficiency suggesting that households with more human capital are relatively efficient in maize cultivation. Monocrop plots are associated with technical inefficiency. To examine whether these results are reasonable we compare with recent findings for Kenya. Liu and Myers (2009) reported elasticity of fertilizers to be 0.224 for production using hybrid maize seed across rural Kenya. The fertilizer variable in Liu and Myers is commodity fertilizer while in this study the variables are nitrogen and combined phosphorous and potassium nutrients. We get elasticity of 0.18 for nitrogen and the confidence intervals include the 0.224 point estimate from Liu and Myers (2009). However, the elasticities for seed and labor from Liu and Myers (2009) are respectively 0.33 and 0.17 while from this study we get negative estimates for seed and far lower estimates for labor. Another recent study is Marenya and Barrett (2009) who find marginal product of 17.64 kilogram per acre for nitrogen and 0.08 kilogram per acre for labor. The model used in their study does not account for phosphorous and potassium application or seeds. Our point estimate is 14.81 kilogram per acre and the confidence intervals include their point estimates of 17.64 kilogram per acre. The marginal productivity of labor from our results is almost half of what is reported in Marenya and Barrett (2009) and therefore not comparable.

We conclude that our results for marginal product of nitrogen are consistent with previous studies, even where fertilizer was defined as a commodity. However, results for seeds and labor are different from previous estimates, and the results for phosphorous and potassium cannot be compared because previous studies did not account for these nutrients.

Table 4.1: Stochastic Frontier Production Model of Maize Production (Translog)

		Half-normal
	LnNitrogen	-0.62
		(1.93)+
	Ln(P+K)	0.10289
		(0.35)
	LnSeed	1.12
		(0.91)
	Lnlabor	0.0494
		(0.31)
	Lnlabor2	0.0458
		(3.92)**
	LnSeed2	-0.1925
		(0.80)
	LnNitrogen2	0.0887
		(3.35)**
	Ln(P+K)2	0.0217
		(0.65)
	LnLabor*LnSeed	-0.1243
		(2.14)*
	LnLabor*LnNitrogen	0.0148
		(0.83)
	LnSeed*LnNitrogen	0.1221
		(1.01)
	Ln(P+K)*LnNitrogen	-0.0236
		(0.81)
	Ln(P+K)LnLabor	0.0005
		(0.04)
	Ln(P+K)LnSeed	-0.0135
		(0.12)
	Constant	6.1984
		(3.89)**
	Group credit	0.00
		(0.46)
	Conventional loans	0.00037
		(1.07)
	Education	-2.9971e-01
		(1.12)
	Age of household head	0.0601
		(1.86)+
	Rented plot dummy	0.6054
		(0.79)
	Monocrop plot dummy	3.6677
		(1.65)+
	Tractor dummy	0.6360
		(0.48)
	Distance to fertilizer	-0.0972
		(1.32)
	Female head dummy	0.9724
		(1.14)
	Constant	-9.7390
		(2.97)**
N		610

The significance levels are:+ *p*<0.1; * *p*<0.05; ** *p*<0.01, Z statistic in parenthesis

To evaluate allocative efficiency we calculate the marginal revenue product of inputs and compare them with factor prices (see table 4.2). The results indicate marginal revenue products are higher than factor prices for fertilizer nutrients (nitrogen and P+K) but lower for seed and labor. We conclude that the average farmer could improve allocative efficiency by increasing use of fertilizer nutrients and reducing seed and labor.

Table 4.2: Summary of elasticity of per acre maize output to inputs and marginal revenue products

Inputs	Translog model			Unit factor prices
	Elasticity	Marginal products	Marginal revenue product	
Nitrogen	0.18	14.81	230.44	35.08
P+K	0.06	31.8	494.81	35.08
Seed	-0.30	-49.70	-773.33	120.17
Labor	0.04	3.89	60.53	106.21

4.5. Impact on Maize Output and Profits

In chapter 2 we estimated the impact of group credit on demand for nitrogen, phosphorous and potassium, and hybrid maize seed. In Chapter 3 we estimated the impact of group credit on demand for adult hired labor and child labor. In this Chapter we have estimated the elasticity of per acre maize output response to nitrogen, phosphorous and potassium, hybrid maize seed, and labor using a translog frontier production function.

The results of the stochastic frontier model with translog production function indicate that a one percent increase in nitrogen rate increases maize yields by 0.18 percent. The elasticity of maize yield to phosphorous and potassium rate is 0.06 and to seed rate is -0.30. Additionally, the elasticity of maize yield to labor rate is 0.04. Next we use these results to estimate the impact of group credit on maize output and profits. To estimate we rely on the conceptual framework in

Chapter 2 section 2.2 – in particular equation 2.6 where the impact of group credit on farm profits is given by:

$$d\pi^*/_{dG} = p\sum_{i=1}^{j}\left(f_i \times {dx_i^*}/_{dG}\right) - \sum_{i=1}^{j} w_i \times {dx_i^*}/_{dG} - r_g = \gamma^*$$

Where ${dx_i^*}/_{dG}$ is the impact of group credit on demand for inputs per-unit land (e.g. fertilizer and seed rates), f_i is the marginal productivity of input i, and γ^* is net impact of group credit on maize profits per-acre. The impact of group credit on maize productivity is given by the product of $f_i(.)$ and ${dx_i^*}/_{dG}$. The monetary value of incremental yield is obtained by multiplying the marginal impact on maize productivity with the price of maize grain $p\sum_{i=1}^{j}\left(f_i \times {dx_i^*}/_{dG}\right)$. The total incremental cost of increased demand for inputs is calculated from $\sum_{i=1}^{j} w_i \times {dx_i^*}/_{dG}$ and the cost of group loans is r_g.

The conclusions from Chapter 2 and 3 are that: (i) that group credit increased demand for nitrogen by 43.65 percent from pre-borrowing levels, (ii) group credit has no impact on demand for phosphorous and potassium or demand for hybrid seeds, (iii) group credit increased demand for adult hired labor by 141.82 percent, and (iv) group credit decreased demand for child labor by 51.82 percent. Based on these results we proceed to extrapolate impacts on maize yields and profits. In this chapter we found that a one percent increase in nitrogen increases maize yields by 0.18 percent. Therefore the incremental demand on nitrogen alone increased maize yields by 7.86 percent (43.65*0.18). The elasticity of maize yield to labor is 0.04 which means a one percent increase in labor rate increases maize yields by 0.04 percent. Assuming that borrowing farmers substituted adult hired labor for child labor the net effect of group credit on demand for labor is about 90 percent increase in demand for labor. The effect on maize yield is about 3.6 percent increase in yields (90*0.04). This means group credit increased yields by about 11.46

percent. The pre-borrowing average maize yield is 1858.95 Kgs per acre and the incremental maize yield is 213.04 Kgs per acre. An average farmer cultivated 2.41 acres and therefore incremental maize output is 513.42 Kgs. Data from secondary sources (FEWS NET, 2009) indicate that average farm-gate maize prices in 2007 were about KES 1,400 per 90 Kg bag[9]. Therefore, the nominal value of incremental output (gross revenue) is KES 7986.47.

Next we account for incremental costs due to fertilizers and hired labor. In Chapter 2 we found that an average farmer increased demand for nitrogen by about 8.53 Kgs per acre. The cost of fertilizer in 2007 was about KES 35.08 per kg and an average farmer cultivated 2.41 acres. It means the cost of nitrogen was about 721.15. The average farmer increased demand for hired labor by 15.70 days per acre which translates to 38.15 days for 2.41 acres. The wage rate in 2007 was about KES 107.30 per day and therefore the incremental wage costs were KES 4093.60. The total incremental cost is KES 4814.75. But this excludes group interest rate of about 10%. When interest rate is accounted for the proportion of loan used for fertilizers and labor the total cost becomes KES 5296.23. The total cost is less than value of incremental output therefore we conclude that group credit increased maize profits by about KES 3171.72 (KES 7,986.47 minus 4,814.75). An average farmer invested KES 4814.75 from group loans to maize production and realized profits of KES 3171.72 which translates to a 65.87 percent return on investment.

4.6. Conclusions

We conclude that group credit is profitable when used to purchase fertilizers and hire labor for maize production. An average farmer invested KES 4814.75 from group loans to maize production and realized profits of KES 3171.72 which translates to a 65.87 percent return on

[9] The farmgate price is obtained after subtracting Kshs 100 (transport cost from farm to market) from average maize price at the nearest Eldoret market– which were Kshs 1,500 per bag.

investment. The average loan size in 2007 was KES 15,760.98 but only KES 4814.75 was used to purchase primary inputs in maize production – which translates to about 30.55 percent. It is plausible that the remaining 69 percent may have been used in non-maize production, perhaps for consumption, short-term investments in competing enterprises (e.g. dairy), and long-term investments such as education. A simple revealed preference argument suggests that although the loans were earmarked for maize production the marginal utility of the loans might have been higher elsewhere. However, it is unlikely group credit was diverted to non-maize fields because of the following: (i) group loans are earmarked for maize fields and released during maize planting; (ii) maize is the most important crop in the study area occupying about 78% of all cultivated fields; and (iii) non-maize fields are not only fewer but also remarkably smaller in size (an average non-maize field is less than one quarter of an average maize field). To evaluate further we estimated the impact of group credit on factor demands in non-maize field and the results indicate no impacts on any factor.

Group credit improves allocative efficiency but has no effect on technical efficiency. The coefficient of group loans in the inefficiency term was not significant. The conclusion that group credit improves allocative efficiency draws from the estimates of marginal revenue products (see table 4.2) and estimates of impact of group credit on factor demands (see chapter 2 for nitrogen and P+K and chapter 3 for labor). We found a positive and significant effect on demand for nitrogen and hired adult labor. Both inputs had positive marginal revenue products indicating that farmers who received group loans improved their allocative efficiency by using more of these inputs. However, the largest marginal revenue products are with P+K and yet access to group credit did not increase demand for these nutrients. We conclude that borrowing farmers could have improved their allocative efficiency even further with increased demand for phosphorous and potassium.

APPENDIX

Non-Parametric regression

To avoid clutter in notation let y_i and x_i represent maize yield and fertilizer rate after purging out z_i (seed and labor rate). The yield response to fertilizers is a conditional expectation function defined as

$$g(x) = E(y_i|x = x_i) = \int y_i \left\{\frac{f_{x,y}(x_i,y_i)}{f_x(x_i)}\right\} dy_i \quad \text{(A4.1)}$$

Where, the numerator $f_{x,y}(x_i, y_i)$ is the joint density of y_i and x_i, and the denominator $f_x(x_i)$ is the marginal density of x_i. The conditional expectation in Equation (A4.1) defines the regression curve of y_i on x_i. The Nadaraya-Watson estimator (Nadaraya 1964, Watson 1964) of the conditional moment is written;

$$\hat{E}_h(y_i|x = x_i) = \frac{n^{-1}\sum_{i=1}^{n} K_h(x-X_i)Y_i}{n^{-1}\sum_{i=1}^{n} K_h(x-X_i)} \quad \text{(A4.2)}$$

Where, n is sample size, K_h is Kernel density function, h is optimal bandwidth parameter, and (Y_i, X_i) are pairwise values of the log of maize yield and log of fertilizer rate respectively. The estimator comprises a weighting function

$$w_i(x, X_i) = \frac{K_h(x-X_i)}{n^{-1}\sum_{i=1}^{n} K_h(x-X_i)} \quad \text{(A4.3)}$$

A number of Kernel density functions appear in the literature and the most common ones are Epanechnikov and Gaussian. Silverman (1986) concludes that choice of kernel functions hardly affects the estimator, but the Epanechnikov yields lowest mean integrated square error and is therefore most efficient. For this reason, this study will rely on the Epanechnikov kernel which is written

$$K_h = \frac{3}{4\sqrt{5}}\left(1 - \frac{h^2}{5}\right)\ if\ |h| \leq \sqrt{5}, otherwise\ K_h = 0 \quad \text{(A4.4)}$$

Table A4.1: First stage Tobit regression of group credit – marginal effects

	Education	417.00
		(1.44)
	Age	66.64765
		(0.47)
	Monocrop	6.8964e+03
		(2.36)*
	Fertilizer	-77.7167
		(0.70)
	Female head	4101.4323
		(0.83)
	Total acres	311.9549
		(0.53)
	Assets listed	0.0091
		(1.84)+
N		395

The significance levels are:+ $p<0.1$; * $p<0.05$; ** $p<0.01$

Z statistic in parenthesis

Table A4.2: First stage OLS regression of conventional loans

Education	793.81
	(3.09)**
Age of head	-2.11320
	(0.02)
Monocrop	-6.2141e+02
	(0.24)
Fertilizer	204.4006
	(2.26)*
Female head	-579.3876
	(0.26)
Total acres	-280.9151
	(1.83)+
Assets	-0.0141
	(0.78)
Constant	326.2531
	(0.06)
R^2	0.03
N	610

The significance levels are:+ $p<0.1$; * $p<0.05$; ** $p<0.01$

Z statistic in parenthesis

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CHAPTER FIVE: CONCLUSIONS

This work makes several important contributions to the literature on the impact of credit constraints on agriculture and the relationship between financial markets and long-term human capital development. First we develop a theoretical model that allows examining not only impacts of agricultural loans but also the pathways through which access to credit affects output supply. This approach provides a fuller understanding of the extent to which innovations in rural financial markets may improve demand for factors, production, and profitability. We conclude that increased demand for fertilizers (nitrogen nutrients) and hired labor is the pathway through which credit may lead to better farm outcomes and profitability. The group credit program had no impact on demand for hybrid maize seeds.

There has been growing interest to understand the relationship between credit constraints and decisions about human capital acquisition, but most studies have examined the effects of negative income shocks on the choice between sending children to school and diverting their time towards labor. The second contribution of this paper is that we examine whether a positive innovation in credit could free child time to investments in human capital development. The result that credit frees child time out of labor suggests that innovations in financial markets may have long-term effects on human capital development if children go to school instead of farms. Therefore, innovations in financial markets should not be evaluated only on the basis of short-term outcomes. Moreover, this result reinforces the importance of first-best mechanisms to address credit market failures in developing countries. Often times, the critical failure in rural credit market is due to information asymmetries between borrowers and commercial lenders, even though this information is available locally between neighbors who often know each other's credit history and historical returns from farming. Group credit programs thrive on their ability to draw on this information, thus providing a first-best intervention.

The third contribution of this paper is that we examine the potential of rural wage labor markets as a mechanism for sharing agricultural surplus to poor landless households. The result that group credit increased demand for adult hired labor suggests rural labor markets can be effective in raising incomes for land constrained but labor abundant rural households – while keeping children away from working in farms. This is an important finding because using rural labor markets as a pathway out of poverty is a challenge that "remains poorly understood and sorely neglected in policy making" – *The World Development Report 2008* (World Bank, 2008). Yet the rural labor force continues to grow at remarkable rates in most developing countries, especially those with an already high share of the world poor.

We also conclude that group credit is profitable when used to purchase nitrogenous fertilizers and hire labor for maize production. An average farmer invested KES 4814.75 from group loans to maize production and realized profits of KES 3171.72 which translates to a 65.87 percent return on investment. The extra profits were realized through improvements in allocative efficiency since neither conventional nor group credit was found to have any relationship with technical efficiency. However, borrowing farmers could have improved their allocative efficiency even further with increased demand for phosphorous and potassium as these nutrients had the largest marginal revenue products.