EFFECTS OF CREDIT AND CREDIT ACCESS ON SMALLHOLDER MAIZE FARMER STORAGE BEHAVIOR IN NORTHERN GHANA

by

ADAM DAVID HANCOCK

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Major Professor
Dr. Vincent Amanor-Boadu

Abstract

Food insecurity affects 16 percent of the population in northern Ghana, making food security a major focus for many of the development programs in the country. A major initiative to overcome food insecurity may involve the development of effective storage systems to help farmers control the flow of their production to markets and, thus, have higher control over the price they receive. While the poor storage infrastructure in the region is known, there is lack of knowledge about the factors motivating farmers to utilize storage in spite of these conditions. The purpose of this paper is to increase understanding about storage behavior of smallholder maize farmers in northern Ghana.

A review of the literature indicates credit plays a large role in storage behavior. The purpose of this thesis is to bridge the gap between literature on storage as a bank, and on storage as a way to ensure food security. Specific objectives include: i) estimating formal and informal credit's effects on storage behavior of smallholder maize growers, and ii) examining the effect of credit at various levels of storage. This analysis is based on data collected on 527 farmers in Ghana's four northernmost regions obtained from an agricultural production survey conducted in 2013 and 2014 by USAID-METSS – a project funded by the Economic Growth Office of the USAID mission in Ghana. Ordinary Least Squares modeling was employed to determine the marginal effects of formal and informal credit on storage. Additionally, quantile regression modeling estimated the marginal effects at different levels of storage, including the median.

The results indicate that formal credit and on-farm storage had statistically significant negative effects on maize storage at both the mean and median, but only farm output proved to be statistically significant at different levels across the storage distribution. On-farm storage had a statistically significant negative effect on storage when compared to storing off-farm at

facilities like local store rooms. Carryover storage from the previous year tested to have statistically significant negative effects on storage. Under the conceptual framework utilized for this study, the results suggest that using formal credit increases a household's food security.

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Chapter 1 - Introduction

Due to agricultural production's seasonal nature, food products are stored to even out fluctuating supply to meet fairly constant demand (FAO, 1994; Nukenine, 2010). The evidence from developing countries suggests that storage serves multiple purposes for smallholder farmers. In addition to leveraging shifts in market supply and prices through arbitrage, smallholder farmers use storage to ensure food security and to store wealth (FAO, 1994; Saha and Stroud, 1994; Tefara et al., 2011). Food security is defined by three components: food availability, food access, and food use (WHO, 2015). Of these, storage helps to ensure food availability in the future**.**

1.1 Storage and Smallholder Farmers

Subsistence farmers who do not produce and store much more than they need for consumption may be forced to choose between ensuring food availability and satisfying immediate cash needs. Immediate cash needs can arise due to unexpected healthcare expenses, birth or death in the family, and other shocks experienced by the household. Households bound by liquidity and credit constraints are likely to sell stored grains to satisfy cash needs even though they may need to replenish storage stocks at a higher price at a later date (Burke, 2014; Stephens and Barrett, 2011). The conditions created by trading-off between meeting short-term cash needs and ensuring long-term food availability can force a resource-constrained smallholder farmer into a poverty trap. Stephens and Barrett (2011) described this as "sell low, buy high" phenomenon, and showed, in the case of Kenyan farmers, how it inhibits smallholder farmers' ability to invest in improving productivity and profitability.

1.2 Formal Credit Access and Smallholder Farmers

Agricultural development and agribusiness literature have linked credit access and usage to loosening smallholder farmers' short term liquidity constraints (Burke 2014; Stephens and Barrett, 2011). Access to credit increases farm profitability by allowing for more optimal usage of inputs if the farm is bound by liquidity constraints, or "credit-rationed". A farmer is considered credit-rationed only if there is excess demand for credit, regardless of the farm's current line of credit. If a farm does not utilize credit and does not demand it, that farm is not considered to be credit-rationed (Winter-Nelson and Temu, 2005). Credit-rationed farms' productivity and profitability are limited by and dependent on credit availability, while performance of farms unconstrained by credit limits is independent of credit availability (Foltz, 2004; Guirkinger and Boucher, 2008). Studies of smallholder farmers in Tunisia and in Tanzania have shown that additional increases in the amount of credit received had a direct positive impact on profitability of farms bound by liquidity constraints, while there was no such impact for farms with no liquidity constraint (Foltz, 2004; Guirkinger and Boucher, 2008).

The importance of liquidity for smallholder storage behavior and food security in developing countries and the positive effect of credit access on reducing liquidity constraints warrant closer examination of the relationship between credit access and storage. Improved understanding of the effect of liquidity and credit access on storage can help in policy efforts to enhance smallholder farmers' food security and eliminate poverty trap conditions due to "sell low, buy high" phenomenon.

1.3 Objectives

The purpose of this thesis is to help bridge the gap between the literature on storage as a bank, and literature on storage as a way to ensure food security and availability. This thesis focuses specifically on an empirical examination of credit's effect on the amount of harvested maize stored by farmers in northern Ghana. The analysis is based on survey data collected from a survey of 527 farmers in the four northernmost regions of Ghana. This thesis uses both Ordinary Least Squares (OLS) and quantile regression modeling to explore the factors that motivate farmers to store their maize production. Specific objectives include: i) estimating the effect of formal and informal credit on storage behavior of smallholder maize growers, and ii) examining the effect of credit at various levels of storage.

The rest of this thesis is organized as follows. The next chapter provides a socioeconomic background on Ghana with insights into its credit markets, and the overview of smallholder agricultural production in northern Ghana. The chapter following that presents the theoretical framework, data, and analysis and the penultimate section presents the results. The principal conclusions of this thesis and the implications for public and private policymakers are presented in the final chapter.

Chapter 2 - Northern Ghana

Ghana is one of the fastest growing developing countries in West Africa. Its agricultural sector, largely comprised of smallholder farmers, contributes 25 percent of the national GDP and is the largest source of employment in Ghana (Wood, 2013; Feed the Future, 2011).

2.1 Poverty and Food Security

Although Ghana is one of the first countries to achieve the United Nation's Millennium Development Goal of halving poverty rates by 2015 (UNDP, 2015), regional analysis reveals disparities in economic growth and development between the northern and southern regions (UNDP, 2012). Despite the country as a whole achieved this goal, there are individual regions within Ghana that did not. The three regions furthest from achieving the United Nation's Millennium Development Goal were the Northern, Upper East, and Upper West, and have become the focus of the United States Agency for International Development's (USAID) Feed the Future Initiative (Feed the Future, 2011). About 16 percent of the population in northern Ghana is food insecure (World Food Programme, 2013) and the combined average household poverty rate is 22.2 percent (Zereyesus et al., 2014). There are concerns that the income gap between the northern and southern regions will continue to widen causing further decline in food security in the north (Feed the Future, 2011).

2.2 Credit Access

The situation with access to credit in Ghana has been described as "low and deteriorating" (Hananu et al., 2015, p. 646). This low level of credit availability impedes agricultural investments and limits the expansion of farm operation (Anang et al., 2015). This in turn limits farmers' abilities to secure more physical assets, leaving farmers locked in a potential poverty trap. Because of perceived liquidity constraints, smallholder farmers in northern Ghana are limited in their ability to increase productivity on one hand, and on the other hand, may experience the need to sell larger portion of their output to meet short-term cash needs at the expense of long-term food availability.

2.3 Storage

Monthly maize prices across Ghana show variability between the harvest season and in the months leading up to next harvest. Following the 2008/09 harvest season, prices fell by as much as 34 percent, and then steadily rose for the remainder of the year (Amanor-Boadu, 2012). Markets characterized by price fluctuations are an implicit condition necessary for the "sell low, buy high" phenomenon. Another implicit condition necessary for this phenomenon is minimal marketable surplus. If a farmer with a minimal marketable surplus were to sell at harvest to meet immediate cash needs, then there would be a need to buy back later in the season at a higher price to ensure sufficient food availability for the household. More than a third of Ghana's agricultural GDP is produced by subsistence farmers who by definition have minimal marketable surplus (FAO, 2006). The combination of observed high seasonal price fluctuations and 29 percent of farmers in northern Ghana being subsistence farmers (Amanor-Boadu et al., 2015) makes northern Ghana an ideal empirical setting for studying food security implications of smallholder farmers' storage behavior and the role of formal and informal credit in addressing "sell low, buy high" phenomenon.

Chapter 3 - Literature Review

Existing literature on credit and storage as they relate to liquidity and food security in developing countries is expansive. However, studies analyzing the storage behavior of farmers using storage as a bank and a way to ensure food security simultaneously are limited. The following chapter contains a discussion of pertinent literature upon which the analysis within this thesis is based.

In addition to literature relating to credit and storage, some studies analyzing market participation are discussed. These studies are relevant to this thesis as the corollary action to not participating in the market would be to utilize storage. The results from these studies are duly noted, but the variables included in these studies would likely not affect storage behavior by the direct inverse of their estimated effect on market participation. The purpose of providing an overview of previous studies is to present the foundation of this study's analysis and to identify how this study contributes to existing literature.

3.1 Storage

Storage is largely utilized by smallholder farmers in developing countries to ensure food availability, meet liquidity needs, and to leverage price and supply shifts (FAO, 1994; Saha and Stroud, 1994; Tefara et al., 2011). The literature on smallholder liquidity and credit access is mostly focused on the effect on productivity (Foltz, 2004; Guirkinger and Boucher, 2008; Winter-Nelson and Temu, 2005). Few studies have analyzed the effect of credit on storage as a source of liquidity (Burke, 2014; Stephens and Barrett, 2011). Other studies on storage have been largely focused on food security and storage conditions (FAO, 1994; Nunekine, 2010; Saha and Stroud, 1994; Tefara et al., 2011).

3.1.1 Credit and Storage

Given the role of storage in satisfying cash needs and in improving a household's food security, farms that do not produce much more than they need for consumption in a given year may be forced to choose between ensuring food security and satisfying immediate cash needs. The works of Stephens and Barrett (2011), and Burke (2014) are some of the most pertinent literature regarding credit's effect on storage as it relates to this thesis. Both studies are based on the principle that liquidity-constrained households may be forced to sell grain in storage to meet cash needs, even though they may have to repurchase grain at a later date to meet food consumption.

Repurchasing grains at some time in the future can negatively affect a household's well-being. When a farming household buys back grain to avoid food insecurity, the lapse in time since selling may come with higher prices. This variation in price comes to the detriment of the farmer. By having to sacrifice long-term food security for short-term cash needs, liquidity-constrained farmers may be force into a poverty trap known as the "sell low, buy high" phenomenon (Stephens and Barrett, 2011). In the context of Kenyan farmers, Stephens and Barrett (2011) show how the "sell low, buy high" phenomenon inhibits smallholder farmers' ability to invest in improving productivity and profitability. Findings relating to a farmer's decision to enter the market show that as the probability of a household's utilization of credit increases by 1 percent, the probability of selling at harvest, when prices are low, decreases 3.3 percent. When interpreting Stephens and Barrett's results on the quantity sold, a 1 percent increase in the probability of using credit resulted in a 1.3 kilogram increase in the quantity of maize purchased at harvest. From purchasing more at harvest and a lower probability of selling at harvest, the study's findings show how credit access may lessen the effect of the "sell low, buy high" phenomenon.

Burke (2014) expanded on Stephens and Barrett's (2011) research of the "sell low, buy high" phenomenon in the context of Kenya. However, this study utilizes an experiment in which farmers were offered microfinance credit in October, at harvest, and then in January. Farmers receiving credit at harvest were shown to have been able to utilize storage more for participating in arbitrage. This study shows that as the need to use storage as means to ensure food security and as a bank to provide liquidity decreases, farmers are increasingly able to use storage as method of participating in arbitrage.

3.1.2 Credit and Liquidity

In addition to the effect of credit on storage behavior, the work of Stephens and Barrett (2011) and Burke (2014) show that credit also affects a farmer's liquidity by enabling farmers to meet cash needs without selling stored crops. Other studies in developing countries have also shown that liquidity can positively affect a farmer's ability to invest in productive assets and the farm's overall profitability if the farmer is liquidity-constrained (Foltz, 2004; Guirkinger and Boucher, 2008; Winter-Nelson and Temu, 2005). In their study of Tanzanian coffee growers, Winter-Nelson and Temu (2005) find that liquidity-constrained farmers under-use chemical inputs in crop production, decreasing overall farm productivity and profitability. Other studies have found similar effects as they relate to smallholder farmers in Tunisia and Tanzania (Foltz, 2004; Guirkinger and Boucher, 2008). By not using more optimal levels of inputs, liquidity-constrained farmers decrease their productivity, and ultimately their income, in order to maintain a certain level of liquidity needed to meet other cash needs.

3.2 Transactions Costs

Transactions costs have been identified as factors affecting market participation as they increase the price paid by buyers and decrease the price received by sellers (Goetz, 1992;

Stephens and Barrett, 2011). Previous empirical studies have further examined how transactions costs should be segregated into proportional/variable, e.g., distance to market, and fixed transactions costs, e.g., extension services, as their effect on market participation can vary (Alene et al., 2008; Key et al., 2000; Omitti et al., 2009). However, Stephens and Barret (2011) find that the distance to market is only a significant determinant in market participation for farmers purchasing at harvest.

3.3 Asset Ownership

Asset ownership has tested to have varying degrees of effect on market participation. These estimated effects vary in their statistical significance, and can be dependent on the degree to which assets are segregated as well if there are any specified interactions with other explanatory variables. However, livestock assets, and assets affecting transportation have tested to have a positive statistically significant effect on market participation (Alene et al., 2008; Goetz, 1992; Lapar et al., 2003). Access to land and land owned per capita also test to have positive and statistically significant effects on market participation (Alene et. al, 2008; Barrett, 2008).

3.4 Demographics

Demographic variables such as household size, dependency ratio, and consumption demand have all been included in analyses of factors affecting market participation. Age of head of household has typically been proven to be significant in marketing behavior (Goetz, 1992; Alene et al., 2008). Cunningham et al. (2008) tested the differences in market orientation between males and females showing that male head of households are more likely to sell early in the season when prices are high. However, households headed by women were more likely to store harvest in favor of household self-sufficiency.

The number of household members can affect both consumption and production (Alene et al., 2008; Gebremedmin and Hoekstra, 2007). Alene et al. (2008) controlled for both consumption demand and labor supply using a variable representing the number of adults in a household. Additionally, households with more members have been shown to grow subsistence crops in order to meet greater demand for food consumption (Gebremedmin and Hoekstra, 2007). Gebremedmin and Hoekstra (2007) also suggested that the more dependents a household had, the more cash needs they would need to meet. The author's results show that increasing an Ethiopian farming household's number of dependents by one dependent increases the probability that that household would produce teff, a staple crop in Ethiopia (Gebremedmin and Hoekstra, 2007).

3.5 Human Capital

In addition to these demographic variables, human capital, most often expressed as a proxy in the form of education, has also been tested to determine its effects on market behavior. Musah et al. (2014) determined that education has a negative effect on market participation, explaining that those with higher education farm only part-time. This effect is enhanced when looking at the production of staple crops which are typically produced for consumption (Musah et al., 2014). However, household heads receiving at least a secondary level of formal education were shown to have a statistically significant positive effect on the proportion of maize the household sold in Omiti et al.'s (2009) study of smallholder farmers in Kenya. The authors postulated that formal education improves a household's understanding of a market's dynamics, allowing the household heads to make better decisions about how much to sell (Omiti et al., 2009).

Human capital can also be represented by the age of a household head. When experience and knowledge is measured in this manner, they are shown to increase with age. Stephens and Barrett (2011) found that age is only significant in determining a farmer's decision to participate in the market as a seller at harvest. Findings show that as a farmer ages, they are less likely to sell at harvest. In terms of the intensity of a farmer's market participation, when a farmer's age is increased by one year, that farmer is estimated to increase purchases by 0.24 kilograms when there is low supply. This finding suggests that older farmers are more concerned with food security.

3.6 Summary of Literature Review

This chapter has served to review some of the current and relevant literature as it relates to this thesis. Although not all relevant literature is included, the findings of previous studies discussed in this chapter served as the basis in the variable selection and the determination of possible covariates when analyzing the effect of credit and credit access on storage behavior.

Chapter 4 - Methodology

The purpose of this chapter is to provide an in-depth analysis of the data and variables included within this thesis. Starting with a broad focus, this chapter begins with a description of the data source used for this study's empirical analysis. Following the first section, information regarding production, credit sources, asset ownership, and household-specific variables will be analyzed.

4.1 Data Description

4.1.1 Data Source

The data used in this study includes secondary data obtained from two surveys sponsored by the Economic Growth Office of USAID|Ghana. The surveys aimed to develop baseline indicators for monitoring the performance of USAID's intervention investments related to the Feed the Future Initiative. The first survey was a population-based survey covering households in the northern regions of Ghana, which served as the Zone of Influence for the Economic Growth Office's intervention programs. The Zone of Influence was determined to be areas of Ghana north of the earth's 8^{th} parallel and included the Upper East, Upper West, and Northern regions as well as eight districts of the Brong-Ahafo region. It was conducted between July and August, 2012 using a two-stage sampling approach structured to produce a sample that was representative of the northern Ghanaian population. The second survey was drawn from agricultural producers in the first survey to develop baseline metrics for agricultural production in the Zone of Influence.

The first survey, had an effective sample size of 4,410 households from 45 districts in four regions of northern Ghana and is representative of northern Ghana as a whole. The second survey's sample of 527 households was drawn from agricultural households identified from the first survey, allowing for the merging of the two datasets in order to facilitate the current study. The final database includes information on demographic characteristics, access and source of credit, as well as storage, marketing, and production information of smallholder maize producers in northern Ghana. .

Given that many households cultivated a number of plots for a variety of crops, data for each household was aggregated to the crop level, and summed for production and usage. Once aggregated, each household had one corresponding data point each for production, consumption, storage, and sales for each major crop produced (maize, rice, and soybean).

4.1.2 Main Crops of Northern Ghana

As maize is the primary crop of interest within this thesis, subsequent analysis is based on households producing maize. The dataset upon which this study's analysis is based originally included 338 maize producing households. To provide a reference of the relative importance of maize in relation to other crops, the frequency of farms producing each crop and how each crop is used are included in Table 4.1.

Table 4.1: Major Crops of Northern Ghana and Their Uses

Crop Name	Frequency Grown	Uses at Harvest (2013)		
		Sold	*Consumed*	*Stored*
Maize	338	28.40%	78.99%	99.11%
Rice	118	37.29%	65.25%	94.92%
Soybeans	60	36.67%	40.00%	95.00%

As this study focuses on maize-producing households, only households that reported having grown maize are included in this study's dataset. Of the 338 households, 118 also grew rice, and 60 households cultivated soybeans. By looking at the percentage of households participating in each activity for a given crop, it can be seen that 37.29 percent of rice producers sold at least some rice at harvest. This represents the largest proportion out of the three main crops. Nearly 37 percent of soybean producers sold at harvest, while only 28.40 percent of maize producers sold any quantity at harvest.

When comparing the percentage of households consuming, and storing a given crop at harvest, maize producers lead all three categories. A considerable portion of producers of all three crops stored some amount of their harvest with over 90 percent of farmers storing for all three categories, but more maize producers stored at harvest than any other crop with 99.11 percent storing some portion of their harvest.

As 78.99 percent of maize-producing households consumed some quantity of maize at harvest, the importance of maize as a dietary staple is evident. Only 65.25 percent of rice producing households consumed rice at harvest while only 40.00 percent of soybean producers sold. When comparing the relative number of farmers selling their crop and consuming it, the data shows that for crops with fewer households consuming at harvest, the proportion of households selling that crop increases.

4.1.3 Credit and Liquidity in Northern Ghana

In order to meet cash needs, farmers utilizing storage as a bank depend on maize as a source of liquidity. However, when farmers receive credit, their dependence on storage as a bank may change. Tables 4.2 summarize the utilization of storage for farmers receiving credit from different lenders as well as sources of collateral and credit-worthiness. At harvest, the 338 maize-producing households included in this study's dataset still had an average of 116.9 kilograms of maize from the previous year in storage.

Table 4.2: Farm Sources of Liquidity and Credit-Worthiness

	Formal		NGO		Informal		Relative		None	
	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*
Credit Utilization (Freq.)	17		22		9		109		195	
Stored at Harvest	418.5	*68.6*	910.7	*186.5*	661.7	*173.6*	585.9	*75.1*	545.4	*56.5*
Carryover	101.8	*33.7*	150.2	*52.4*	5.6	*3.7*	102.2	*15.1*	126.1	*21.2*
% of Households										
Outright Land Owner	76.5		72.7		100.0		75.2		75.4	
Extension	35.3		40.9		0.0		31.2		26.2	

Depending on interest levels, or the need of repayment, farms receiving credit may adjust their storage depending of the source of lending. By analyzing at the level of lending sources, it can be see that households borrowing from informal sources retained an average of 5.6 kilograms of maize from the previous year while all other households, including those reporting to have not borrowed, stored more. Producers borrowing from formal financial institutions stored the least at harvest, averaging 418.5 kilograms of maize. This could be a result of interest and loan repayment being due at harvest, or that farmers with access to formal credit do not use storage as a bank as much as other farmers. However, without empirical analysis this cannot be determined.

Carryover storage may also be used as collateral, in addition to land that a farmer owns outright. Across the various sources of credit, the proportion of households that owned land outright varied only slightly between 72.7 and 76.5 percent with the exception of households borrowing from informal lenders; all of those households were outright land-owners. However, households with informal lenders providing credit also reported never having been members of extension organizations. Households not borrowing represented the second-lowest proportion of households having been members of extension organizations at 26.2 percent. Thirty-five percent of farmers borrowing from formal institutions reported having been or currently being members of extension organizations while 40.9 percent of households borrowing from non-governmental organizations (NGOs) were members at some time.

Table 4.3: Sources of Credit and Forms of Credit Utilized by Maize Producers

Credit Source	**Frequency**	**Form of Credit**					
		Cash Only		In-Kind Only		Cash and In-Kind	
		Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*
Formal	17	17	100.00	0	0.00	0	0.00
NGO	22	13	59.09	8	36.36	1	4.55
Informal	9	7	77.78	0	0.00	2	22.22
Relative	109	82	75.23	15	13.76	12	11.01

The different types of lenders may offer credit in different forms. Farmers receiving credit in the form of cash may alter their storage practices differently than a farmer receiving in-kind credit. Table 4.3 presents summary statistics regarding the forms of credit each credit source offered to the farmers in this study.

Farmers in this data set reported receiving two forms of credit, and some received a combination of the two. Formal and informal institutions largely provided credit in the form of cash, with informal institutions extending only cash credit to 77.78 percent of their borrowers and offered a combination of cash and in-kind credit to 22.22 percent of borrowing farmers. Formal institutions only offered cash credit.

NGOs extended cash credit to 59.09 percent of farmers borrowing from them, and offered in-kind loans to 36.36 percent. One farmer (4.55 percent) received both cash and in-kind credit. Farmers borrowing from their friends and relatives received in-kind 13.76 percent of the time, the largest proportion of all credit sources, and only cash 75.23 percent of the time. Eleven percent of farmers receiving credit from friends and family received both cash and in-kind credit.

Moving forward, this thesis categorizes farmers receiving credit from formal institutions and NGOs as having received “formal” credit. Farmers receiving credit from friends and family, or other informal sources are categorized as having received “informal” credit.

4.1.4 Maize Production and Usage at Harvest in Northern Ghana

As credit loosens liquidity constraints, farmers having received credit may utilize resources differently, affecting output. Farmers with credit access may also alter their market participation and storage behavior at harvest as their cash needs and means of meeting cash needs may differ from farmers not receiving credit. Table 4.4 presents information regarding the different uses of maize for farmers in the dataset receiving credit from different sources.

Maize farmers receiving credit from NGOs both produced and sold the most of their harvest, averaging 1,359.1 and 206.8 kilograms, respectively. Farmers borrowing from formal institutions sold a smaller quantity at harvest than other farmers, averaging 33.5 kilograms, and stored an average of only 418.5 kilograms, the smallest quantity out of all other groups. This finding should be noted as credit from formal institutions could provide a greater degree of liquidity than any other source of credit, and maize which is one of the better, if not the single best, source of liquidity for farmers not receiving any credit. Based on findings from table 4.3, this would follow intuition in that formal institutions only extended cash credit, and cash is the most liquid asset.

Table 4.4: Household Maize Uses at Current-Year Harvest by Credit Source

	Formal		NGO		Informal		Relative		None	
	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*
Credit Utilization (Freq.)	17 (5.0%)		22 (6.5%)		9 (2.7%)		109 (32.3%)		195 (57.7%)	
Produced	708.2	*120.7*	1359.1	*232.9*	861.1	*216.2*	836.9	*86.9*	705.9	*48.6*
Sold	33.5	*23.7*	206.8	*92.0*	15.6	*11.4*	57.6	*14.1*	43.6	*11.4*
Stored	418.5	*68.6*	910.7	*186.5*	661.7	*173.6*	585.9	*75.1*	545.4	*56.5*

4.1.5 Household Demographics in Northern Ghana

The average age of household heads borrowing from informal institutions was the highest out of all other groups at 52.3 years of age. Additionally, households borrowing from friends and relatives were headed by members that averaged 43 years of age.

Table 4.5: Household Demographics by Credit Source

	Formal		NGO		Informal		Relative		None	
	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*	Mean	*Std. Err.*
Age	47.6	*3.3*	49.1	*3.5*	52.3	*5.3*	43.0	*1.5*	46.4	*1.3*
Household Size	11.3	*1.6*	10.6	*1.0*	8.7	*0.8*	10.9	*0.6*	9.9	*0.4*
Dependency Ratio	1.7	*0.5*	1.1	*0.2*	1.5	*0.4*	1.4	*0.1*	1.3	*0.1*
% of Households										
Female Head	11.8		4.6		22.2		8.3		8.2	

Average household size among households within each group ranged between values near 9 and 11 members with households borrowing from informal institutions having the smallest average household size at 8.7 members. The average dependency ratio across the various sources of lending ranged between 1.1 children per adult and 1.7 children per adult with those borrowing from NGOs representing the minimum, and those borrowing from formal credit institutions representing the maximum. The values of average dependency ratios across the different sources of credit are not too different than that of households that did not borrow for any source, especially when standard errors and sample sizes are considered. From this observation, it could be that lenders do not particularly find households with more or less dependents relative to the number of adults a valuable determinant in whom they choose to extend credit.

Households borrowing from friends and relatives, those not borrowing from any source were represented by a similar proportion of female-headed households with respective values of 8.3 and 8.2 percent. However, only 4.6 percent of households borrowing from NGOs were headed by females. Female-headed households borrowing from formal and informal institutions represented 11.8 and 22.2 percent of households in each category, respectively. This result may indicate that lending institutions may prefer female lenders more strongly than NGOs.

Although some general relationships can be drawn from these population statistics, the power of inference gained from these results is limited without empirical analysis. The following section describes the conceptual framework in which this study's empirical analysis is based.

4.2 Conceptual Framework

The conceptual framework used in this study assumes that a smallholder farmer's utilization of storage practices yields an unobservable level of utility which is subject to a household-specific budget constraint and available storable grain. Following Renkow (1990), a farmer's utility from storage may be conceived of as a function of expected profit from selling the stored commodity later versus now, current liquidity level, and the farmer's convenience yield, defined as the yield necessary for meeting household consumption needs. This relationship can be formally presented as follows:

$$U = f(\mathrm{E}(\pi), \mathrm{L}, \mathrm{Y}) \tag{4.1}$$

where U denotes the level of utility from storage, $\mathrm{E}(\pi)$ denotes the expected profit from selling the stored commodity later as opposed to now, L denotes the level of liquid assets, or in other words, the extent to which immediate cash needs may be met, and Y denotes the convenience yield. Following this model, the observed quantity of crop stored at harvest can be used as a proxy for the farmer's level of utility from storage.

With respect to liquidity, credit reserves can be equivalent to on-hand cash and cash substitutes. The use of credit reserves as cash substitute does not have a large impact on a farm's asset structure and involves relatively low transactions costs (Barry et al., 1981). In developed countries, such as the US, formal sources of credit are generally available in rural financial markets (Barry et al., 1981). Due to the availability of formal credit sources, farmers in developed countries are able to acquire credit to meet liquidity constraints with relative ease. However, in northern Ghana, and developing countries in general, the availability of credit from formal sources is poor, leaving on-hand cash and cash substitutes such as storable grain as the only options to address short-term liquidity needs. For credit-rationed and inherently cash-constrained subsistence farmers, selling storable grains is the main solution to meeting immediate cash needs (Stephens and Barrett, 2011).

Subsistence Farmers

A subsistence farmer's production includes minimal marketable surplus as production is primarily motivated by meeting future consumption needs, both food- and cash-related. Because of these described roles, storage acts as a type of bank for subsistence farmers. Some cash needs are unpredictable and cannot be included in a farmer's estimation of future needs. Therefore, the quantity in storage would be equal to the product of average food consumption for a given time period for the entire year and the number of time periods remaining in a given year in addition to the quantity needed to meet expected future cash needs. This value can be determined by dividing a household's expected cash needs by the expected per-unit price in time *t* when a household needs to meet cash needs [$E(Q^c) = \frac{E(C)}{E(P_t)}$]. This can be presented formally by the following equation:

$$Q_t^s = \overline{Q^f} * (n - t) + E(Q^c) \tag{4.2}$$

where Q_t^s is the quantity in storage at time *t*, $\overline{Q^f}$ is the average household food consumption within a given time period, *n* is the number of time periods within a year, *t* is the amount of time since harvest, and $E(Q^c)$ is the quantity of maize needed to meet expected cash needs in the future.

A time period could be measured in days, weeks, months, or any other measure of time smaller than a year. At harvest, *t* is equal to zero and the total quantity stored would be denoted $Q_{t=0}^s$. The quantity stored to meet food consumption for the year is $\overline{Q^f} * n$.

If a credit-rationed subsistence farmer was faced with meeting unexpected cash needs, she would be forced into selling a portion of her quantity in storage. At this point *t*, Q_t^s decreases by C/P_t, where *C* is the total value of cash needs and P_t is the per-unit price of maize at time *t*. As maize prices drop in response to increases in available supply, farmers may receive lower prices per unit sold as *t* approaches zero. As the price of maize increases following the reduction of available supply, the quantity needed to be sold by a farmer to meet the same cash need decreases. This relationship can be thought of as an appreciation in the value of maize relative to cash, represented by α. When the available supply decreases after harvest, price will likely increase. In this case, P_t would be positively correlated with t and Q_t^s would be negatively correlated with t and P_t.

If actual cash needs (C/P_t) are greater than what the farmer originally expected, ($E(C)/E(P_t)$) the farmer will have to sell a portion of her storage intended for food consumption in order to meet cash needs. At this point, the new level of maize storage ($Q_t^{s\prime}$) will fall below the level of maize storage needed to meet a household's food consumption for the remainder of the year (Q_t^f), making the farming household food insecure. As the household consumes food from storage over time, the level of storage decreases according to the household's average food consumption. At some point in time before the next harvest, $t+i$, the farmer's household will run out of food. In this case, $t+i=j$ where j is the number of time periods before harvest and $n-j$ is the amount of time the household will be food insecure until the next harvest.

The quantity of maize by which a household will be food insecure is equivalent to the decrease in maize stored from meeting cash needs (C/P_t) in excess of what was expected ($E(Q^c)$) divided by the average household consumption within a given time period ($\overline{Q^f}$). Therefore, when the quantity remaining in storage meets the level of average consumption at time $t+i$ ($Q_{t+i}^{s\prime} = \overline{Q^f}$), the farmer will be forced to buy purchase enough maize to meet consumption needs until the following harvest. This value is denoted as $\overline{Q^f} * j$. Given the seasonal variability in crop prices, the lapse in time since the original sale at time t would likely have come with higher prices which would mean the farmer would have to buy maize at a higher price at time $t+i$ than which she had sold it at time t. The increase in value of maize relative to that of cash is defined by an inflation rate, α. Therefore, the buy-back price of maize in time period $t+i$ will be $P_t(1+\alpha)$. Larger differences between the new price, $P_t(1+\alpha)$, and the original price, P_t, would make farmers increasingly worse off as they would have to use more money to that could have been used for productive purposes, but instead must be used to meet food consumption. This scenario characterizes the "sell low, buy high" phenomenon, and results in the farmer facing more obstacles to overcome poverty.

The total loss in value to the farmer from selling low and buying high can be calculated by multiplying the buy-back price, $P_t(1+\alpha)$, by the difference between the initial quantity reduction in storage at time t and the quantity needed to meet household food consumption for the remainder of the year, and then adding the product of price at time t and the expected quantity needed to meet cash needs $[P_{t+i}*[(C/P_t)-(\overline{Q^f}*j)]+[P_t*E(C)/E(P_t)]]$. This scenario is represented graphically in Figure 4.1. The grey area represents the amount of time that the household would be food insecure if it were to not purchase more.

Credit has been shown to increase short-term liquidity to credit-rationed farmers, and to increase productivity and profitability as they are limited by and dependent on credit availability (Burke, 2014; Foltz, 2004; Guirkinger and Boucher, 2008; Stephens and Barrett, 2011). As such, it is believed that when a farmer is faced with meeting cash needs, it is then that credit is used to meet short-term liquidity, rather than selling stored maize. It is postulated that from this function of credit, the previous scenario may be modified for farmers with access to credit in that when faced with a total value of C cash needs, the farmer would utilize credit to meet the cash needs in excess of her expectations of cash needs, and in doing so, she avoids selling maize intended for food consumption. By utilizing credit, the decrease in storage is limited to that which was originally expected, maintaining a level of storage necessary to meet future food availability ($Q^{s\prime\prime} = Q^f$). In doing so, the farmer does not have to purchase maize at time $t+i$ for a higher price as her household will not be food insecure, and avoids the “sell low, buy high” phenomenon.

However, as storage serves as a type of bank with a cost of storage (interest rate) equivalent to the losses from spoilage, farmers will utilize credit so long as their cost of storage is less than the interest accrued from borrowing. If the unexpected cash needs are realized before some time *p*, where planning for the coming year’s production has been finalized, farmers may adjust production accordingly in order to satisfy debt obligations. The issue of repayment is satisfied at the following harvest, decreasing the initial amount stored for subsistence farmers receiving credit. This scenario is represented in Figure 4.2. One key difference between Figure 4.1 and Figure 4.2 is that the household in Figure 4.2 does not have a grey area representing a period of food insecurity. From the scenario represented in Figure 4.2, the following general hypothesis may be proposed:

1) ***H_1*** – Credit access can reduce a farming household’s reliance on storage as a bank and help address the “sell low, buy high” phenomenon.

Farmers utilizing credit to meet cash needs are faced with two options: i) use credit to wholly offset cash needs so that they need not sell maize at time *t* and ensuring to a greater degree of certainty that they will be able to meet future consumption demand ii) sell maize to meet cash needs to the point where the level of storage is equal to consumption demand for the remainder of the year (Q^s=Q^f). The outcome of this decision is dependent on the interest of the loan, the rate at which maize appreciates relative to cash, and the cost of storage. Although farmers may or may not have to pay a monetary value for storage, all farmers are subject to the possibility of maize spoiling while in storage. The combination of these two factors equate to the economic cost of storage. Farmers would utilize credit only if the interest accrued from borrowing was less than the sum of the appreciation rate of maize relative to cash and the cost of storage ($i < \alpha + cost\ of\ storage$).

If a farmer were to utilize credit, she may be obligated to interest payments or loan repayment at the coming harvest. So long as this decision were made by time *p*, the farmer could adjust production to partially account for these obligations. Farmers successfully meeting payment obligations could make storage decisions at harvest of the following year under the assumption that they could utilize credit in a similar manner as before. Under H_1, these farmers would be less bound by liquidity constraints and depend less on storage as a bank. At the harvest of the following year, these farmers may decrease storage as storing to meet future cash needs would decrease. In terms of equation (2), Q_t^s would converge to $\overline{Q^f} * (n - t)$ as $E(Q^c)$ approaches zero.

Figure 4.1: Subsistence Farmers without Credit

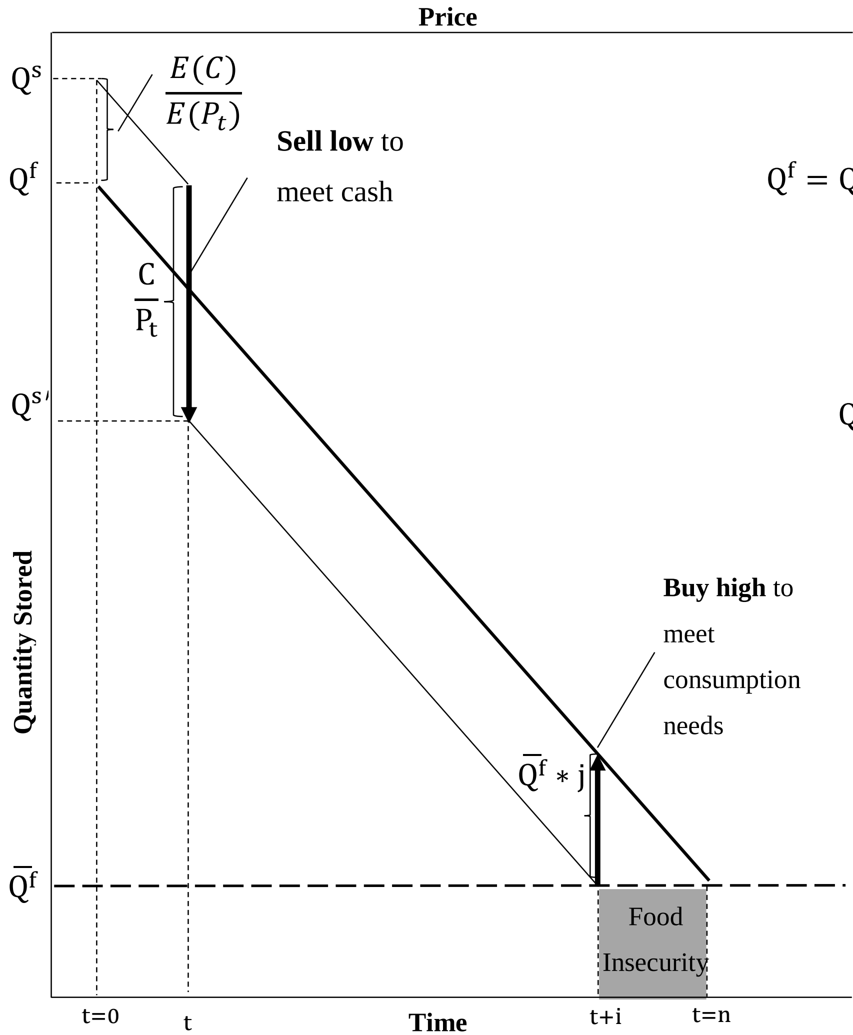
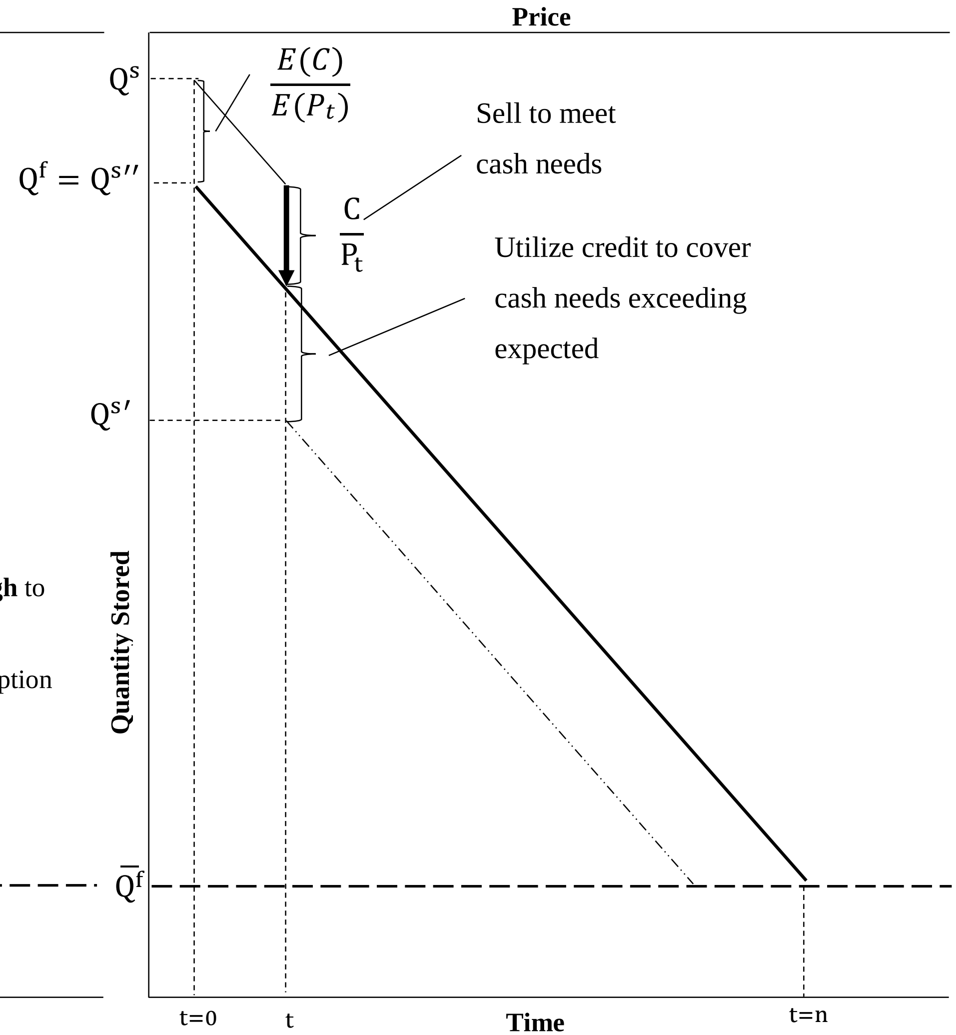


Figure 4.2: Subsistence Farmers with Credit



Smallholder Farmers

Beyond subsistence farmers that produce almost no marketable surplus (MS), there are smallholder farmers that produce enough to have a marketable surplus. The quantity of maize stored could be presented by the following equation:

$$(4.3) \qquad Q_t^s = \overline{Q^f} * (n) + E(Q^c) + MS$$

Farmers whose storage practices are characterized by equation (3) are more food secure. In this case, farmers needing to meet cash needs would first sell the quantity which they expected to need for meeting cash needs ($E(Q^c)$). If cash needs exceeded this quantity, the farmers would then sell a portion of their marketable surplus, and then, as a last resort, they would begin selling the maize stored for future food consumption. If the farmers had to begin selling maize intended for future food consumption, the result would be similar to that depicted in Figure 4.1, so this scenario will not be expanded on further within this section. However, for the purposes of this study, the scenario in which cash needs exceed what was expected and farmers begin selling a portion of their marketable surplus needs to be further explained.

In Figure 4.3 and Figure 4.4, line Q^{f+ms} represents the sum of the quantity needed to meet food demand and a farmers marketable surplus. When a farmer producing marketable surplus must sell maize at time *t* the line Q^s shifts to $Q^{s\prime}$. If this quantity is greater than that which was expected to be needed to meet cash needs, $E(Q^c)$, the farmer must sell part of her marketable surplus (MS) and $Q^{s\prime}$ would lie at some point below Q^{f+ms}. Because $Q^{s\prime}$ is still greater than Q^f, the farmers still has some marketable surplus which is sold at time $t+i$ for some higher price P_{t+i}. The price at which a farmer sells her remaining MS is equal to the price at which she originally sold to meet cash needs adjusted for the appreciation of maize relative to cash (P_{t+i}=P_t(1+α)). The revenue gained from the sale of marketable surplus is the product of P_{t+i} and the difference between $Q^{s\prime}$ and Q^f. This scenario is represented in Figure 4.3. It should be noted that this scenario does not involve a farming household being or becoming food insecure.

If a farmer producing marketable surplus were to receive credit, she would be faced with three options when needing to meet cash needs: i) use credit at time *t* to meet cash needs and forego selling her maize until prices rise, ii) sell maize at time *t* to meet cash needs, and use credit to buy maize at harvest, when prices are low, or iii) sell some quantity of maize at time *t* that is equal to $E(Q^c)$ and use credit to cover the remaining cash needs, selling her marketable surplus at time $t+i$ for revenue and to cover costs of repayment. This decision would be dependent on the interest accrued on the credit, the cost of storage, and the rate at which the value of maize appreciates relative to cash. If the interest accrued is less than the sum of the cost of storage and the rate of appreciation, α, then a farmer would utilize some credit at the time *t* when she must meet cash needs. Figure 4 illustrates the scenario in which this condition holds, and the farmer uses credit to cover cash needs exceeding $E(Q^c)$.

The additional revenue gained from the usage of credit is represented by the grey area in Figure 4 and is equal to the product of P_{t+I} and the difference between $Q^{s\prime\prime}$ and $Q^{s\prime}$. The total value gained from this scenario would be the difference between the sum of the amount owed and the cost of storage, and the product of the quantity sold at time $t+i$ and the price of maize at that time.

Farmers in these scenarios are able to produce at a level to meet food-related and cash-related consumption needs with additional marketable surplus ($Q^s_{t=0} > \overline{Q^f} * n$), and are better suited to meet cash needs without making them more food insecure. Both of these scenarios incentivize increasing storage quantities at harvest. From this, as farmers depend less on storage as a type of bank, and their food security increases, they may increasingly engage in speculative behavior. This type of storage behavior is in contrast to that which H_1 is based, but is due to differences in the quantity stored at harvest. To this end, the scenarios in which storable marketable surplus is produced allow another general hypothesis to be presented as follows:

2) ***H_2*** – Access to credit can have varying effects on storage behavior of farmers storing different quantities across the distribution of storage.

Figure 4.3: Marketable Surplus Produced without Credit

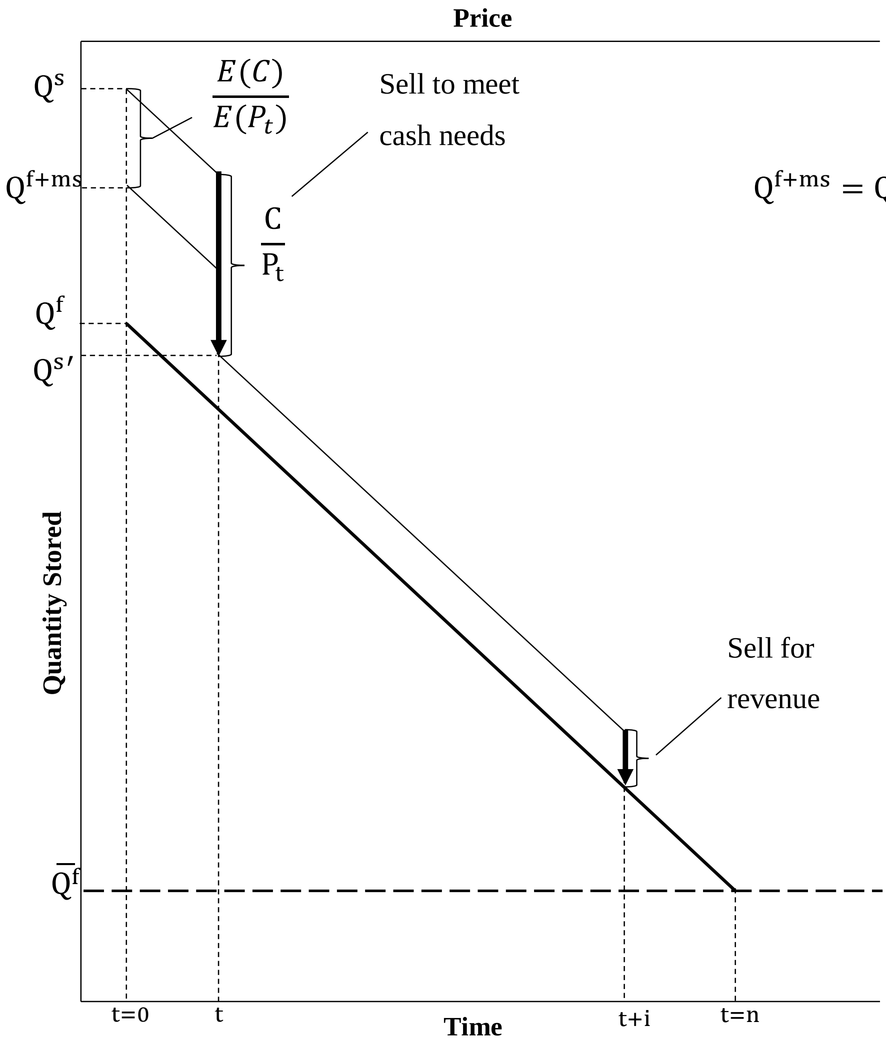
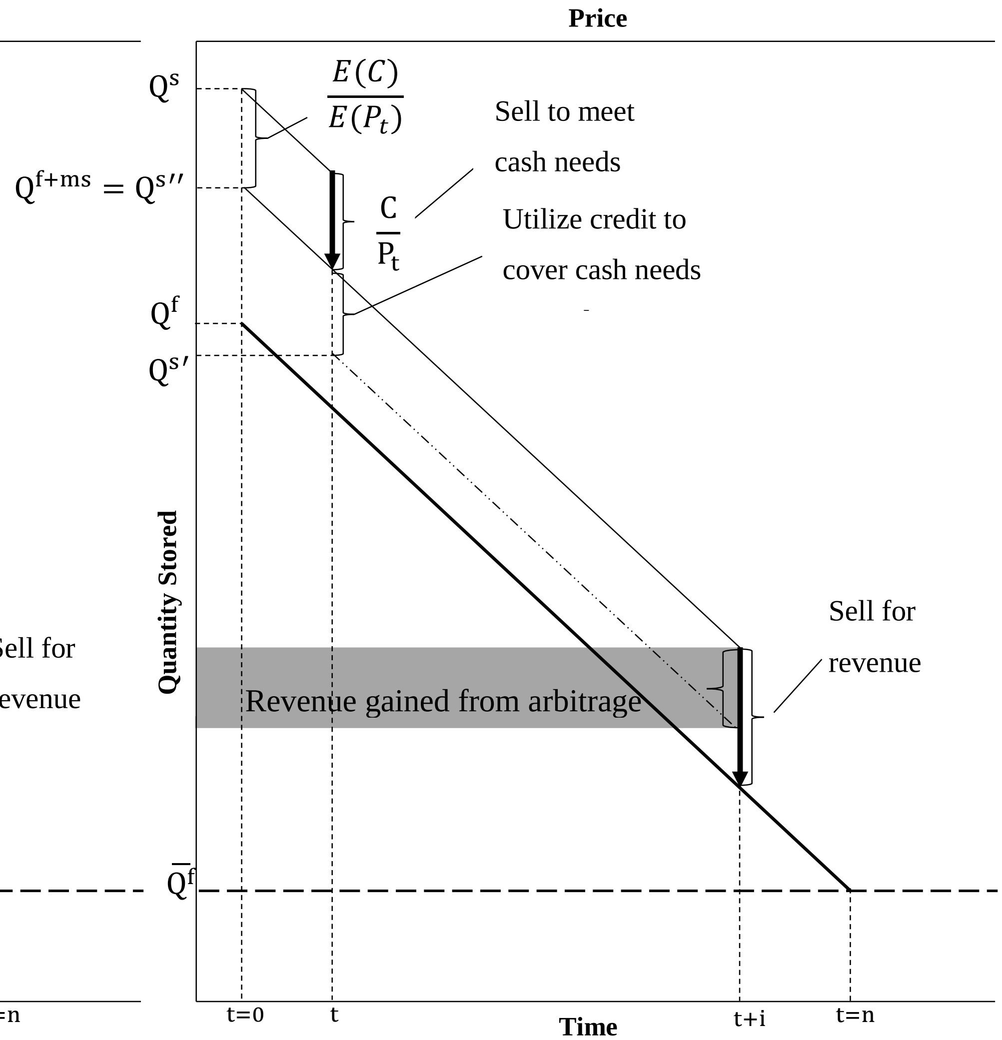


Figure 4.4: Marketable Surplus Produced with Credit



4.3 Model Estimation

In order to test the proposed hypotheses, this study utilizes the quantile regression method by use of Stata's *sqreg* command. Commonly used to estimate the effects of education on earning, conditional quantile regressions segment the dependent variable's distribution so to regress given percentiles of the dependent variable, Y, on X, a given vector of covariates. Doing so provides different coefficient estimates of each covariate in X for a given percentile τ.

(4.4) $$Q_\tau(Y|X) = \beta_{i\tau}X$$

where τ indicates the τ^{th} percentile to which a given parameter β_i belongs for each given covariate of X. Each parameter β_i may vary with τ due to the τ^{th} percentile of the unknown error distribution of ε_τ.

Quantile regression regresses about the median of the dependent variable's distribution, and at the median (50^{th} percentile), the estimates are independent of a given value of a covariates, also referred to as unconditional. Ordinary Least Squares (OLS) modeling also provides unconditional estimates, but in contrast, regresses about the mean of the dependent variable's distribution. In practice, if the dependent variable is distributed normally, the mean and median estimates will be similar. However, in the case of a dependent variable with a skewed or multimodal distribution, the estimates will vary. Using an unconditional quantile estimate for skewed distributions gives a better representation of a covariate's effect on the dependent variable since an unconditional estimate estimated about the mean will not be as representative of the whole population.

A study conducted by Koenker and Hallock (2001) shows that in the context of demographics as they relate to birthweights, at birth the mean effect of birthweight on gender is that males are 100 grams larger than females. However, quantile regression analysis indicates that at the lower tail of the weight distribution, the effect is smaller, and at the upper tail of the distribution, the effect is greater than 100 grams. Other demographic variables, such as race and the mother's weight gain show similar disparities, and also show significant differences in the mean and median effects of each variable on a child's birthweight. Based on the conceptual framework established in this thesis, it is believed that quantile regression may provide useful insights into better understanding a smallholder maize farmer's storage behavior.

To this end, the quantity of maize stored is defined as *S* and is a function of credit, access to credit, liquidity situation, and convenience yield (as described above), controlled by the demographic and socioeconomic characteristics of the decision-maker. Thus, we reframe Equation (4.1) as follows:

$$\text{(4.5)} \qquad S_\tau = \alpha_\tau + \beta_{1\tau}\pi + \beta_{2\tau}L + \beta_{3\tau}Y + \sum_{i=1}^{K} \gamma_{i\tau} x_i$$

where the variables are as defined and x_i is the vector of demographic and socioeconomic characteristics of the decision-maker and the α_τ, β_τ and γ_τ are the estimated coefficients at the τ^{th} percentile. Additionally, S_τ is the τ^{th} quantile of the distribution of quantity of maize output stored at harvest. Equation (4.5) is estimated to determine the statistically significant variables motivating the quantity of maize stored in the study area.

Estimating this model requires careful consideration due to potential endogeneity issues. The quantity of maize output stored serves as the dependent variable, but liquidity constraints may be addressed through selling stored maize. Additionally, stored maize may be used as collateral for credit from lenders. Both of these conditions would introduce issues of reverse-causality. To address these issues, the quantity of maize carried over from the previous year was included as it could be used to address liquidity issues, or serve to supplement future consumption. The maize remaining in storage from the previous year's harvest may also serve as collateral for credit from lenders. The effect of this variable on the dependent variable may vary depending on the function the carryover storage serves.

To further control for assets able to be used as collateral, information regarding land ownership is included. The variable indicates whether farmers are outright owners of the land or not. Land ownership is expected to have a positive effect on storage as land owners would be less likely to use maize as collateral for credit access because they could instead offer their land as collateral.

Maize is a relatively liquid asset compared to others possessed by smallholder farmers, such as land. Consequently, when the quantity of stored maize decreases relative to output, a farmer's overall liquidity decreases as well. To this effect, the quantity of maize remaining in storage at the time of harvest relative to the output of the previous year is used as a measure of a farmer's liquidity at the time of harvest and is expected to have a negative effect on the quantity of maize stored at the coming harvest as more maize can be sold to meet cash needs.

Binary variables are also included that represent whether a household received credit from formal sources, such as formal lending institutions or NGOs, or informal sources, such as friends and family or other informal sources are also included to capture a household's participation in credit markets. The effects of each credit source are expected to both have negative effects on storage at harvest.

The control exogenous variables included were gender, age, distance to market and storage location. Other variables were price, household size, dependency ratio, output from production and sales at harvest. Cunningham et al. (2008) showed that women were more likely to store crops to ensure food security. Dependency ratio, measured as the number of children per adults in the household, is expected to have a positive effect on proportion stored as higher dependency ratio would increase the importance of supplying own food to ensure food availability.

Transactions costs have been identified as factors affecting market participation as they increase the price paid by buyers and decrease the price received by sellers (Goetz, 1992; Stephens and Barrett, 2011). Previous empirical studies have further examined how transactions costs should be segregated into proportional/variable, e.g., distance to market, and fixed transactions costs, e.g., extension services, as their effect on market participation can vary (Alene et al., 2008; Key et al., 2000; Omitti et al., 2009). Through categorizing transactions costs and their effect on market participation, it is hypothesized that fixed transactions costs would have a negative effect on intensity of storage as farmers had already incurred these costs and could spread them over more maize sold at market. Proportional transactions costs were hypothesized to have a positive effect as an increase in proportional costs cannot be as easily spread over more units sold.

Other variables included in this study's analysis were the dependent variable, quantity of maize stored at harvest time, quantities produced, sold, or consumed at harvest; price received for sale at harvest; and location of storage facilities - Costs of rent and transportation to facilities away from farm could reduce incentive to store. Demographic variables included were household head's gender and age – Age serves as a proxy for human capital which could lower transactions costs through existing knowledge. Cunningham et al. (2008) showed that women were more likely to store crops harvested to ensure food security. Each household's dependency ratio, measured as the number of children per adults, is also included. Households with more children may store more at harvest since they are expected to have higher consumptive demand for maize. Additionally, households with more members may store more to meet future consumption, so household size is also included.

4.3.1 Modeled Data

The revenue variable was measured in Ghanaian Cedis (GHS). For the APS, per unit price data was not collected, but total revenue (GHS) and aggregate quantity sold (kg) were collected. The price per unit variable was created by dividing a household's total revenue from sales by the household's total quantity sold. The dependency ratio was calculated as the number of children/the number of adults in a given household. This ratio serves as a measure of contributing household members.

Table 4.6: Summary Descriptive Statistics of Selected Variables in Estimation Model

Variable		**Mean**	**Std. Err.**	**95% Conf. Int.**	
Stored	Maize stored at harvest (kg)	582.03	42.65	498.13	665.92
Carryover Storage	Maize still in storage at harvest (kg)	116.88	13.66	90.01	143.74
Formal	1= Farmer received credit from formal lender or NGO	0.11		0.08	0.15
Informal	1= Farmer received credit from friends, relatives, or other informal source	0.35		0.30	0.40
On-farm Storage	1= Farmer utilizes on-farm storage	0.57		0.51	0.62
Female	1= Female household head	0.08		0.02	0.11
Outright Landowner	1= Farmer is outright landowner	0.76		0.71	0.80
Maize Price/kg	Ghanaian Cedis (GHS)	0.38	0.18	0.03	0.73
Dependency Ratio	Number of children per adult in household	1.35	0.06	1.24	1.46
Farm Output	Maize harvested during the current year (kg)	792.31	43.44	706.87	877.76

The population sample is heavily weighted by households headed by males with 92 percent of the sample reporting to be male-headed households. Eleven percent of the sample population received credit from formal lenders and non-governmental organizations while 35 percent received credit from informal sources such as friends and family members. Total farm output for 2013 averages 792.31 kilograms with a standard error of 43.44 kilograms. The average quantity of maize stored at harvest is 582.03 kilograms. Carryover maize remaining at harvest averages to be 116.88 kg. The binary variable for storage location was relatively evenly distributed with 43 percent utilizing off-farm storage facilities such as local store rooms. Through analyzing summary statistics for storage off-farm and on-farm the mean quantity of maize stored off-farm is 696.22 kilograms whereas on-farm storage averaged 494.14 kilograms. On-farm storage has a smaller variance with a standard deviation of 466.27 kilograms, compared to off-farm's standard deviation of 1054.98 kilograms. The average per-unit price of maize at harvest is 0.38 GHS.

Chapter 5 - Results

The hypothesis regarding credit reducing a farming household's reliance on storage as a bank (H_1) is tested using OLS estimation, as well as quantile estimation at the 50th percentile of the storage distribution. The other proposed hypothesis regarding the varying effect of credit on storage behavior for farmers storing different quantities (H_2) is tested using quantile estimation at the 10th, 25th, 50th, 75th, and 90th percentiles of the storage distribution. The variables of interest are formal and informal credit.

5.1 Estimation Results

Table 4.1 presents the estimation results for the effect of credit on smallholder maize farmer storage behavior in northern Ghana. OLS estimation results are included under the first column, followed by results from quantile estimation. Conditional quantile estimates are provided for the 10th, 25th, 75th, and 90th percentiles of the storage distribution where τ=.10, .25, .75, .90, respectively. The 50th percentile (τ=.50) represents the unconditional estimation results for quantile estimation. For OLS and quantile results, estimated coefficients are reported with robust and bootstrapped standard errors, respectively, in parentheses. Results from testing for coefficient equality under quantile estimation are included in the last two columns. Based on the results from equality testing, only farm output is estimated to have effects statistically different from each other across the analyzed percentiles at the 1 percent significance level; the remaining eight coefficients did not test to have statistically significant different effects across the storage distribution at the 10 percent significance level or lower. These results indicate that OLS estimation is a better fit for the data included in this study. Correlation analysis was performed to test for possible multicollinearity issues between the covariates. Variance Inflating Factors were less than two for all variables, indicating that multicollinearity is not a major concern under this specification.

Table 5.1: Summary Regression Estimation Results

Variable	Coefficient							
	OLS	*10th Percentile*	*25th Percentile*	*50th Percentile*	*75th Percentile*	*90th Percentile*	*F (4,328)*	*Prob> F*
Carryover Stock	-0.21 **	-0.08	-0.26 *	-0.07	0.00	0.04	1.27	0.28
	(0.10)	(0.08)	(0.14)	(0.09)	(0.06)	(0.04)		
Formal	-118.25 *	-49.16	-73.08	-64.22	-42.01	-5.48	0.35	0.85
	(69.61)	(62.75)	(87.21)	(40.58)	(33.17)	(44.73)		
Informal	-59.19	-14.11	4.80	-1.48	-1.90	15.38	0.51	0.73
	(52.05)	(19.51)	(15.36)	(12.98)	(15.44)	(24.67)		
On-farm Storage	-123.50 **	-46.22 *	-21.10	-19.01	-19.61	-19.43	0.33	0.86
	(59.74)	(23.59)	(21.23)	(13.89)	(13.90)	(35.01)		
Female	13.06	-28.56	-6.25	20.47	6.64	25.97	1.30	0.27
	(46.28)	(21.73)	(40.18)	(16.61)	(25.36)	(161.62)		
Outright Landowner	19.35	-5.76	-7.35	3.67	11.43	-0.53	0.39	0.81
	(42.34)	(13.82)	(18.17)	(14.33)	(12.87)	(17.46)		
Maize Price/kg	-2.87	4.68	1.89	-1.10	-2.21	-3.90	0.02	1.00
	(2.00)	(26.45)	(35.59)	(25.67)	(26.81)	(20.62)		
Dependency Ratio	26.57	-10.38	-5.10	-3.86	-0.42	24.74	0.41	0.80
	(22.41)	(8.57)	(11.66)	(5.85)	(6.83)	(35.16)		
Farm Output	0.77 ***	0.32 ***	0.57 ***	0.79 ***	0.88 ***	0.93 ***	19.62	0.00
	(0.05)	(0.07)	(0.06)	(0.04)	(0.02)	(0.02)		
Intercept	46.12	67.58	27.42	1.11	0.05	4.60	2.70	0.03
	(63.96)	(20.14) ***	(21.83)	(13.74)	(16.62)	(45.23)		
R2	0.6113	0.2239	0.3497	0.5144	0.6335	0.671	N=	338

***,**,* denote significance at the 1, 5, 10 percent significance levels, respectively.

5.1.1 Hypothesis Testing

Hypothesis 1

OLS estimation results show that formal and informal credit access both have negative effects on a farmer's quantity stored at harvest with formal credit testing to be statistically significant at the 10 percent significance level. Under quantile regression, at the median of the storage distribution, formal and informal credit access are also shown to have a negative effect on storage. These effects did not test to be statistically significant at the 10 percent significance level or lower. The estimated effects follow expectations under H_1.

Informal credit did not test to be statistically significant at at least the 10 percent significance level under either estimation method. Under OLS regression, four of the nine variables tested to be statistically significant at the 10 percent significance level or lower, and only farm output tested to have statistical significance at the 1 percent significance level. Under quantile regression, only one unconditional estimate tested to be statistically significant. This significant variable, farm output, tested to have statistical significance at the 1 percent significance level, as in the OLS estimation.

Hypothesis 2

Across the different percentiles tested in the quantile regression the effect of formal credit is shown to become less negative as τ approaches a value of one. A similar effect was expected under H_2. The only level of storage with estimated effects in contradiction to expectations is the 10th percentile, under which the effect of formal credit is estimated to be less than that at the 25th and 50th percentiles. However, testing for coefficient equality shows that the conditional estimates are not statistically different from each other at the 10 percent significance level or lower.

The effect of formal credit access on quantity stored did not test to be statistically significant at the 10 percent significance level for any percentile along the distribution of storage. Estimates for the effect of informal credit on storage varied under quantile estimation, but there is no clear directional trend when comparing the effects across percentiles. No conditional estimate for informal credit tested to be statistically significant at the 10 percent level of significance. Testing for equality reveals that the estimates for informal and formal credit access are not statistically different from each other at the 10 percent significance level.

5.1.2 Formal Credit Sources

The coefficient signs across the OLS and quantile estimates for the effect of formal credit follow expectations under both hypotheses presented within this study with only one exception in the case of the 10th percentile, where the relative magnitude was unexpected. Formal credit tested to be statistically significant at the 5 percent significance level for the unconditional quantile estimate, and tested to be statistically significant at the 10 percent significance level under the OLS specification. With an estimated coefficient value of -118.25, under OLS regression formal credit is estimated to decrease the quantity of maize stored at harvest by an average of 118.25 kilograms, ceteris paribus. Formal credit is also estimated to decrease the median of the storage distribution by 64.22 kilograms at harvest, and is estimated to have less of an effect on storage levels at the 25th percentile. Based on estimation results, farmers located at this level in the storage distribution decrease maize storage by 73.08 kilograms when using formal credit. The effects of formal credit on storage at the 75th and 90th percentiles are both smaller in magnitude than the previous estimated percentiles with farmers reducing storage at harvest by 42.01 kilograms, and 5.48 kilograms, respectively. At the 10th percentile, the effect of formal credit on storage is smaller than that at both the 25th and 50th percentiles. Although the magnitude of this effect conflicts with what was expected, the directional effect follows expectations. Compared to all other variables, formal credit is estimated to have a greater effect than any other variable for all levels and methods of estimation.

5.1.3 Carryover Storage

The estimated effect of carryover storage on a farmer's storage behavior at harvest follows expectations across both OLS and quantile estimates with two exceptions for the conditional quantile estimate of the 75th and 90th percentiles. At the 75th percentile, the estimate has a value of 0.00, interpreted as a one kilogram increase in carryover does not affect storage at the current harvest. The conditional estimates of carryover storage's effect on current-harvest storage become less negative as τ approaches 1 and actually becomes positive at the 90th percentile. This trend is violated at the 10th percentile where the coefficient's magnitude is less than that at the 25th percentile. Only one of the 25th percentile estimate tested to be statistically significant at the 10 percent significance level, but the coefficients did not test to be statistically different from each other at at least the 10 percent significance level. However, under OLS estimation the effect is statistically significant at the 5 percent significance level and can be interpreted as a one kilogram increase in carryover storage decreases storage at the current year's harvest by 0.21 kilograms, on average.

5.1.4 Informal Credit Sources

Borrowing from informal sources is estimated to have a negative effect on maize storage under OLS regression, but estimates from the quantile regression have a positive value at the 25th and 90th percentiles. The quantile estimates do not follow a noticeable trend of increasing or decreasing as τ approaches 1. At the median, farmers borrowing from informal lenders are estimated to decrease maize storage by 1.48 kilograms whereas at the mean informal credit is estimated to decrease maize storage 59.19 kilograms, ceteris paribus. None of the estimates tested to be significant at the 10 percent significance or lower for both the OLS model and the quantile model. After testing for coefficient equality, the null hypothesis that the conditional quantile estimates are equal cannot be rejected at the 10 percent significance level.

5.1.5 On-farm Storage

When estimated using OLS specification, storing on-farm has a negative effect on the quantity of maize stored at harvest. Under quantile specification, this effect also proved to be negative across all percentiles estimated. This result follows expectations as off-farm storage is likely to have better quality resulting in lower costs of storage, and larger capacity. On-farm storage tested to be statistically significant at the 5 and 10 percent significance levels for the OLS estimate and the conditional estimate at the 10^{th} percentile. For the OLS estimate, the effect can be interpreted as on average, storing on-farm decreases the quantity of maize stored by 123.50 kilograms as opposed to storing off-farm at a facility such as a local store room. When τ is increased beyond .10, the coefficient estimates under quantile specification become less negative than at the 10^{th} percentile, and also decrease in statistical significance, not testing to be statistically significant at at least the 10 percent significance level. Testing for coefficient equality results in a failure to reject the null hypothesis that the effect of storage location on quantity stored is the same across all estimated percentiles at the 10 percent significance level.

5.1.6 Female

The variable representing female-headed households was estimated to have a positive effect on quantity stored at harvest when estimated both at the mean, and the median, indicating that females store more than males. The OLS estimate can be interpreted as households headed by females store on average 13.06 more kilograms than male-headed households. When estimated under quantile specification, the median maize storage at harvest increases 20.47 kilograms for female-headed households. This result follows expectations and previous literature which finds females are more likely to store to ensure food security than males. At 10th and 25th percentiles of the storage distribution, however, female-headed households are estimated to store less than those headed by males. None of these estimates tested to be significant at any level of significance at or below the 10 percent significance level. Also, the conditional quantile estimates did not test to be statistically different than each other at the 10 percent significance level.

5.1.7 Outright Landowner

The results show that being an outright landowner is estimated to have a positive effect on a farmer's quantity of maize stored at harvest when specified in the OLS model. When regressed at the mean, farmers that are outright land owners store 19.35 kilograms more than if they were not to own their land outright, ceteris paribus. At the median of the storage distribution, the effect of outright landownership on quantity stored is smaller, but still positive and can be interpreted as farmers that are outright land owners at the median of the storage distribution store 3.67 more kilograms of maize at harvest than if they would were they not outright owners of land. Across the estimated percentiles, the effect of outright landownership on storage is estimated to vary, not following a noticeable trend as τ approaches 1. None of the conditional estimates tested to be statistically different from each other at the 10 percent significance level under the quantile-specified model, and neither the quantile nor OLS estimates tested to be statistically significant at the 10 percent significance level or lower.

5.1.8 Maize Price/kg

Maize price per kilogram was determined to have a negative effect on quantity stored at harvest when regressed both at the median and the mean. Under OLS specification, a one cedi increase in the per-unit price of maize at harvest (GHS/kg) would reduce the quantity stored by 2.87 kilograms, on average. This estimate is not statistically significant at the 10 percent level of significance. At the 50th percentile, the same one cedi increase in per-unit price would decrease the quantity of maize stored by 1.10 kilograms. As it relates to food security, at lower levels of storage, the effect of price on storage is positive for farmers at both the 10th and 25th percentiles. This effect is negative at the 50th percentile and becomes increasingly negative as τ approaches one. Following intuition, at lower levels of storage, farmers are less food secure and may interpret higher prices as a sign of an impending food shortage and increase their storage to ensure to a greater degree that they have enough food to meet consumption needs. As the quantity of maize in storage increases, farmers become more food secure and can decrease their storage when prices are higher to take advantage of higher prices. However, the coefficients did not test to have effects statistically different from each other across the storage distribution at the 10 percent significance level.

5.1.9 Dependency Ratio

The estimated effect of a household’s dependency ratio varies between the results of the OLS specification and quantile-specified model. When regressed at the mean in the OLS model, if a household’s dependency ratio were to increase by one, on average the quantity of maize in storage would increase by 26.57 kilograms. This estimate follows expectations as having more children dependent on the same number of adults would likely increase storage since children may not have as many methods of obtaining food as adults.

Under quantile specification, the effect of a one unit increase in a household's dependency ratio is estimated to decrease the median quantity of maize stored by 3.86 kilograms. Across the different percentiles, the estimated effect becomes more negative as τ approaches 0 and less negative as τ approaches 1. At the 90th percentile the effect of a household's dependency ratio becomes positive, with a one unit increase in the dependency ratio being estimated to increase storage at the 90th percentile by 24.74 kilograms. Testing for coefficient equality, the null hypothesis that the effect of a household's dependency ratio is the same across the storage distribution fails to be rejected at the 10 percent significance level. Additionally, no estimate under the OLS- or quantile-specified models tested to be statistically significant at the 10 percent level or significance or lower.

5.1.10 Farm Output

A farm's level of output as measured in kilograms of maize tested to be statistically significant the 1 percent significance level for every estimate in the OLS and quantile models. Comparing the unconditional estimates from both specifications, the median and mean effects are of similar values, with the OLS estimate being 0.77 and the estimate at the 50th percentile being 0.79. Interpreting these values, a one kilogram increase in harvest output increases the quantity of maize stored at harvest by 0.77 kilograms, on average, under OLS specification. Under quantile specification, a one kilogram increase in farm output increase the median quantity of maize stored by 0.79 kilograms.

Across the different percentiles, the effect of farm output on quantity stored at harvest increases at a decreasing rate as τ increases from .10 to .90. This result can be interpreted as farmers producing more store more at harvest relative to other farmers storing similar amounts.

These effects also tested to be statistically different from each other across the different percentiles of the distribution at the 1 percent significance level.

Chapter 6 - Discussion

The OLS estimation results suggest that formal credit access decreases a farmer's maize storage at harvest by 118.25 kilograms, on average. Under the quantile specification, formal credit access decreases the median quantity of maize stored by 64.22 kilograms. Informal credit access has a negative, but not statistically significant effect on storage based on results from the OLS estimation. These results provide support for the first proposed hypothesis that credit reduces a farming household's reliance on storage as a bank.

Carryover stock has a negative and statistically significant effect on storage at harvest of the current year under the OLS estimation, significant at the 5 percent significance level. Results suggest that for one additional kilogram carried over from the previous year, storage at harvest of the current year decreases by 0.21 kilograms. This effect follows intuition as remaining storage reserves decrease the need for farmers to store their current harvest to meet future consumption demand and food availability needs, one of the potential uses proposed within this study. The quantile estimation shows that the effect of carryover stock on storage at harvest is decreasingly negative as storage increases, and turns into a positive effect at the 90th percentile. One exception to note is that at the 10th percentile, the estimated effect is less negative than that at the 25the percentile. Although the effect of carryover stock is only statistically significant for farmers at the 25th percentile, the observed trend could suggest that farmers storing more are increasingly using storage as means for taking advantage of shifts in prices and supply.

Storing on-farm is estimated to have a statistically significant negative effect on the quantity of maize stored under the OLS estimation. On-farm storage is estimated to decrease storage by 123.50 kilograms, on average, when compared to off-farm storage at facilities like local store rooms. Off-farm facilities may be superior in reducing spoilage and may also have higher capacities (Nunekine, 2010). By reducing spoilage, farmers utilizing off-farm facilities, or even facilities of improved quality, could be able to leverage their production in similar ways as farmers with carryover stock at the 90th percentile of the storage distribution. On-farm storage was also estimated to have negative impact on storage quantities across all percentiles analyzed in the quantile estimation. The 10th percentile is the only estimated percentile testing to have a statistically significant effect at the 10 percent level of significance or lower. This could be due to variations in storage location mostly affecting farmers at low storage levels as that could be the binding constraint in their quantity of storage. This effect would explain the unexpected relative magnitudes of the estimates for carryover, and both formal and informal credit access at the same percentile.

The effect of price on storage in the OLS estimation suggests that higher prices decrease the quantity of maize in storage. Following economic theory, farmers receiving higher prices are shown to sell more maize. This effect is similar in magnitude for the median, and 75th percentiles under the quantile regression analysis. However, at the 25th and 10th percentile levels, farmers facing a higher price increase the quantity stored. As a higher price could be seen as a sign of impending supply shortages, farmers storing lower quantities would face a higher risk of food insecurity and inability to meet future food availability needs. Although none of the estimates tested to be significant at at least the 10 percent significance level, this is an interesting finding within the context of the "sell low, buy high phenomenon".

Farm output tested to be statistically significant at the 1 percent significance level for all conditional and unconditional estimates analyzed in the quantile and OLS regressions. This variable is also the only one to have coefficient values statistically different from each other for the conditional estimates. The effect of farm output on quantity stored increases in magnitude as storage level increases. At the 90th percentile, a one kilogram increase in farm output increases storage by 0.93 kilograms, almost a unit-for-unit increase. The effect's upward trend could suggest that farmers with higher levels of storage increase storage at harvest to transfer the abundant supply to times where there is more of a scarcity in supply.

Chapter 7 - Conclusions

This thesis analyzed the storage behavior of smallholder maize farmers in northern Ghana. In an effort to better understand how credit and credit access affects farmers vulnerable to the "sell low, buy high" phenomenon, this study aimed to better understand how farmers utilize credit to loosen liquidity constraints so that they may need immediate cash needs without risking sufficient food availability in the future. In particular, this study focused on subsistence and smallholder maize farmers in northern Ghana, and how different forms of credit affect their storage behavior.

The main results from this thesis suggest that farmers receiving credit from formal and informal sources decrease storage at harvest. Through the utilization of credit, these farmers are able to meet their immediate cash needs without sacrificing future food availability, and food security in general. This finding supports the proposed hypothesis that credit access can reduce a farming household's reliance on storage as a bank and help address the "sell low, buy high" phenomenon. Related to Stephens and Barrett's (2011) findings, credit access decreases binding liquidity constraints, particularly that of formal credit. Findings from this study are in opposition to those of Burke (2014) who found that through offering loans at harvest, Kenyan farmers stored *more* maize at harvest and utilized storage more as a way of taking advantage of shifts in price and supply.

In addition to improving overall food availability for a farmer, credit's loosening of binding liquidity constraints could improve smallholder farm productivity and profitability as both are dependent on credit availability (Foltz, 2004; Guirkinger and Boucher, 2008).

Based on the results presented within this study, policymakers may look to improve credit access in northern Ghana, and other developing countries as it allows liquidity-constrained farmers to meet unexpected immediate cash needs without sacrificing future food availability and food security.

The findings from this study and the framework established within are observed in the context of northern Ghana, as the implicit conditions necessary for the “sell low, buy high” phenomenon were found to be present. However, other regions and developing countries may prove to be well suited for similar analyses.

7.1 Limitations and Future Research

Research analyzing the effects of credit on storage both as a type of bank, and as means of ensuring food security and availability is limited. Although this thesis aimed to bridge the gap between these bodies of literature, this study does have some limitations that should be considered in future research.

As the data used in this study is secondary data, collection of the data was not motived solely by this study. This thesis uses the data as best as possible, but having additional data regarding the timing and quantity/volume of cash needs and receiving credit. Using variables representing these data would allow researchers to gain better insights into i) when farmers are faced with cash needs ii) how farmers meet cash needs regarding selling stored grains and/or utilizing credit.

Additionally, future research should seek to incorporate some time component. This possibility is implicitly related to the possible extensions just described, but should be explained explicitly. By observing cash needs and credit utilization over time, future studies would be able to match the time a household faces cash needs with the source of liquidity the household used to meet their cash needs. In doing so, more insights could be provided relating to if households use credit to meet liquidity needs or to offset costs of repurchasing grains at higher costs in order to meet food security needs.

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