EFFECTS OF AGRICULTURAL VALUE CHAIN FINANCING ON POTATO PRODUCTIVITY AND MARKET ACCESS ON FARM HOUSEHOLD'S LIVELIHOOD IN MUSANZE AND NYABIHU DISTRICTS, RWANDA

PATRICE MUGENZI

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented for the award of any other degree in Egerton University or any other university.

Signature:  Date: 07/02/2023

PATRICE MUGENZI

KD19/12286/16

Recommendation

This thesis has been submitted with our approval as University supervisors.

Signature: _  Date: 07/02/2023

Prof. George Owuor, PhD

Department of Agricultural Economics and Agribusiness Management

Faculty of Agriculture

Egerton University

Signature ___  _____ Date: 07/02/2023

Prof. Hillary K.Bett, PhD

Department of Agricultural Economics and Agribusiness Management,

Faculty of Agriculture

Egerton University

DEDICATION

This thesis is dedicated to my late father, my mother, my wife Consolée Mujawamariya, and my daughters: Parfaite Umuhozawase, Céline Uwimpuhwe, Henriette Uwurukundo, Marie Christella Uwihirwe Shimwa Nelly and Angel Michella Ineza Mugenzi for their encouragement and inspirations.

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May the favour and grace of the Almighty God be with you all**.**

ABSTRACT

Potato (*Solanum tuberosum L.*) is an important crop that plays a major role in food security and poverty reduction in Rwanda. However, lack of adequate agricultural financing approach remains the major challenge to low production and increased poverty, especially for smallholder farm households and other actors in potato value chain. The general objective of this study was to contribute towards the increased potato productivity and improved access to potato market for enhancing the smallholder farm households' livelihood in Musanze and Nyabihu Districts, Rwanda. The research has used quantitative survey to collect data from 585 smallholder potato farm households consisted of 275 (47.01 %) users of agricultural loans while 310 (52.99 %) non-users of the agricultural loans in their potato activities. With STATA 16 and SPSS 16, data were analysed using descriptive statistics. Probit model estimates, Propensity score matching, Endogenous switching regression and Double Hurdle and Multivariate Probit Models were also used. The study discovered that the household head's age, household head's education level, the distance to the produce market, household income, and membership to farming organizations all had a significant and positive influence on the farmers' decisions to participate in and use of agricultural financing approaches. Farming experience, household head' sex and marital status and had a negative and significant influenced the farmers' decisions to participate and use of agricultural value chain financing. The study found that farm households that allocated credit to potato production harvested 5.150 metric tons while those who did not allocate credit to potato production harvested 1.658 metric tons, which makes 3.492 metric tons (211%) more than them. Furthermore, the findings revealed that that the household head' sex, and membership to farming organizations increased the farm householder's willingness to participate in the potato market. It also found that the probabilities for farm households to sell to processors, brokers, wholesalers, retailers and consumers were -15.2 %, -88.4 %, -116.8 %, , -24.9 %, and -82.8 % respectively, while the probabilities to sell to collection centres and cooperatives were 76.1% and 32.3% respectively. The study revealed that there is 0.13 % likelihood for farmers' choices to sell to all the seven market outlets and 3.7 % of not selling to the seven market outlets simultaneously. The study recommended policy makers' interventions for developing loan products, affordable interest rates suitable to the desires and capabilities of farmers and creating a well-structured market system that enables smallholder farmers to access to the market information. Potato farmers would also upgrade their education in farming systems and marketing so as to produce and deliver quality produces.

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LIST OF ABBREVIATIONS AND ACCRONYMS

ADB:	Asian Development Bank
AFR:	Access to Finance Rwanda
ATT:	Average treatment effect on the treated individuals
AVC:	Agricultural value chain
AVCF:	Agricultural Value Chain Finance
CIP:	Crop intensification programme
EAC:	East African Community
ESR:	Endogenous switching regression
FAO:	The Food Agricultural Organization of the United Nations
FRW:	Franc Rwandais (Rwandan francs)
GDP:	Gross domestic products
GMA:	Gross Margin Analysis
GoR:	Government of Rwanda
IFAD:	International Fund for Agricultural Development
IIRR:	International Institute of Rural Reconstruction
KES:	Kenya Shilling
KIT:	Royal Tropical Institute
MINAGRI:	Ministry of Agriculture and Animal Resources
MVP:	Multivariate Probit
NISR:	National institute of Statistics of Rwanda
EICV:	Enquête Intégrale sur les Conditions de Vie des ménages (Integrated Household Living Conditions Survey)
PSM:	Propensity Score Matching
RAB:	Rwanda Agriculture and Animal resources Development Board
ROSCAS	Rotating Savings and Credit Associations
SACCO:	Savings and credit cooperatives
SSA:	Sub Saharan Africa
SPSS:	Statistical Package for the Social Sciences
UNEP:	United Nations Environmental programme
US$:	US dollar
WB:	World Bank

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Many countries in Africa, especially of sub-Saharan Africa (SSA), heavily rely on agriculture and agroindustry for employment and economic development and transformation(Djoumessi et al., 2019). Agriculture is identified by United Nations as a crucial sector to achieve the Sustainable Development Goals (SDGs), goal one (no poverty) and goal two (zero hunger) (FAO, 2018). In fact, Van Den Broeck and Maertens (2017) report that agricultural transformation is an essential component of poverty reduction in developing countries, particularly of SSA. Transformation of the agricultural sector catalyses industrial growth and structural transformation, thereby creating employment, earning foreign income, ensuring food security, increasing incomes, and contributing to poverty reduction (Odusola, 2017). These are critical impact pathways that development practitioners are targeting in order to enhance the agricultural sector's contribution to the prosperity of African coutries.

The agricultural sector is the main driver of economic growth and development in Rwanda. Rwanda registered 10.9% growth in gross domestic product (GDP) in 2021 with agriculture contributing to 24% of the national GDP in the same year (W.B, 2022). Agricultural raw material accounts for 1.46% of Rwandese merchandize exports while food exports accounted for 34% of merchandize exports. The sector also employs about 62% of the country's labour force (W.B, 2022). However, the smallholder farmers dominate the agricultural sector and produce roughly three-quarters of country's agricultural produce (Mugisha, 2022). These statistics highlight the importance of the agriculture and smallholder farmers to economic development of Rwanda.

The Rwandan government has prioritized agriculture as the economic engine as envisaged in its development blueprint. The agricultural transformation blueprint focuses more on expanding production and improving farm level productivity. Although the transformation requires massive investment in technology and market development (Martey *et al.,* 2012), the sector has a potential of contributing on the improved the farm household members' livelihoods. One of the interventions involves increasing farmers' access to improved seeds of staple food (Kim *et al.,* 2022). Other interventions involve good agronomic practices (fertilizer), post-harvest handling practices, and mechanization (Kim *et al.,* 2022). However, despite the government's agricultural transformation intervention, the sector remains

subsistence-oriented and productivity and transition to market-oriented farming has stagnated in recent times (Heinen, 2022). These calls elicited rethinking of structure public and private investments at different levels of agricultural value chains of priority crops in the countries.

Potato (*Solanum tuberosum* L.) "Ibirayi" derived from "Uburayi" ("that which comes from Europe"). It is an important tuber crop grown throughout the world. The crop originated from Andean mountains of Peru and Bolivia (Monteros-Altamirano *et al.*, 2022). Potato crop is the fourth most important food crop in the world after rice, wheat, and maize, and holds a great potential in ensuring both food and nutritional security in many regions (Ortiz & Mares, 2017). In 2020, global potato production was 359 million tons from 16.5 million hectares (FAOSTAT, 2022). Globally, more than one billion people consume potatoes (FIOC, 2019). Asia and Europe are the world's major potato producing continents accounting for 80% of the world production (NETAFIM, 2017). In contrast, African production turns only around 5% of the world production, yet the crop has the potential of contributing to alleviation of poverty and malnutrition problems.

Potato is one of the new emerging crops that are central to the Rwanda's economic development agenda (Tenge *et al*., 2012). It is one of the six priority crops (maize, wheat, rice, potato, cassava, and beans) listed under crop intensification program (CIP) by the Ministry of Agriculture and Animal Resources (Kim *et al.*, 2022). The crops play tremendous role in enhancing security, nutrition, employment, and socio-economic wellbeing of smallholder farmers in the country (MINAGRI, 2013), implying that it is indispensable to rural development. Potato is an important source of income and excellent contributor to food security in Rwanda (Brenneis & Fortenbacher, 2016). This is due its short maturity period (approximately 90-120 days) compared to other food crops and nutritional properties (carbohydrates, protein, vitamin C, calcium and potassium) (Jarén *et al.*, 2016). Thus, potato production is entirely attractive to smallholder farmers (Ritter *et al*., 2017) with limited resources and capacity to manage production and marketing risks.

Rwanda is the tenth largest potato producer in Africa, seventh in SSA, and third in Eastern Africa Community after Kenya and Tanzania (FAOSTAT, 2022). In 2021, Rwanda produced 858,521 tons of potato from 104,494 hectares (FAOSTAT, 2022). Potato production in Rwanda is concentrated in high altitude zones of North-West and Eastern Congo-Nile highlands of Burera, Gicumbi and Musanze (Northern Province), Nyabihu and Rubavu (Western Province), Nyamagabe and Nyaruguru (Southern Province) (Brown *et al.*, 2012) which produce 80 % of national potato output. The other regions in the country are

marginal potato producers (Muhinyuza *et al.*, 2012). The average consumption of potato is 0.125 metric ton per year and up to 0.150 metric ton per year in some areas of Northern and Western provinces where production of potato is very intensive.

However, the potato sub-sector in the country is plagued by several factors that need urgent solution to safeguard the role of the crop in food security and national development. While many factors plague potato productivity, availability and accessibility to high yielding improved potato varieties undermine the efforts of smallholder farmers to optimize potato yield (Muhinyuza *et al.*, 2012; Nshimiyimana *et al.*, 2015). For instance, potato seeds cost more than 50% of the total inputs cost. Furthermore, farmers have limited choices of varieties and are therefore forced to use recycled planting materials saved from previous harvest or acquired from nearby markets. In addition, farmers have limited access to fertilizers which impede improvements in potato yields. Despite Rwandan government interventions, the average potato yield remains 10 and 11 metric tons per hectare which is three times lower than a potential of about 30-40 metric tons per hectare attainable yields (NISR, 2015).

Furthermore, government of Rwanda has embraced liberalization in the last three decades, opening opportunities for trade of Rwandese products as smallholder farmers greatly improve the quality and quantity of their agricultural products, trade can enable them to access markets and benefit from that market integration. However, despite the significant development of agro-industrial sector and the role played by smallholder farmers in the supply of agricultural produces, agricultural marketing remains a critical issue in Rwanda. Farmers lack abilities to acquire basic farm services and farm inputs and abilities to supply farm products to markets (Tilburg& Schalkwyk, 2012). The perishability of the produce as well as inadequate access to market information, high transportation costs, lack of inadequate storage facilities, and high transaction costs impede potato marketing (Kyomugisha *et al.*, 2018; Taiy *et al.*, 2016). They also represent the major hindrances to farm households in selling their yield on time and at various output markets (Ahmed *et al.*, 2016). Smallholder farmers are unable to compete with larger and better endowed commercial farmers who have access to information, services, capital and earn excessive margins from lucrative markets. This results in increased market prices to consumers and reduced income to smallholder farmers, thereby converging to food insecurity and poverty (Ahmed *et al.*, 2016). Therefore, the issues related to access to agricultural markets, marketing channels, and market outlets need to be adequately addressed.

Research has mainly focused on identifying and finding solutions to potato productivity constraints such as seeds, pest, and diseases (Ferrari *et al.,* 2017; Muhinyuza *et al.,* 2012; Nelson *et al.,* 2016; Nshimiyimana *et al.,* 2015; Uwamahoro *et al.,* 2018). However, there is lack of emphasis on financing the product and post-harvest fonctions of potato value chain. In response, the government of Rwanda, through the Ministry of agriculture has attempted to reduce the financial constraints by introducing agricultural financing programs like rural investment facility, post-harvest and agribusiness support project, small and medium enterprise guarantee fund, and sustainable credit guarantee scheme. Nonetheless, access to adequate and affordable financial services in agriculture remain pervasive and poorly distributed. Despite the available programs, financial institutions continue to perceive agriculture as costly and risky sector. They hesitate to extend credit to rural farmers (Oberholster *et al.,* 2015) and thus leave the agricultural sector inadequately financially serviced.

Therefore, there is a need for a financing agriculture and food systems, which is, funding linkages between actors along the value chain and financial institutions to increase stakeholders' returns and to ensure sustainability and efficiency within the chain. In this context, an understanding of the agricultural value chain financing frameworks would boost potato productivity, improve farmers' access to markets and generate more responses to the challenges encountered by farmers, and guide the policymakers and other development partners in their initiatives to revitalize the potato value chain in Rwanda.

1.2 Statement of the problem

In Rwanda, the demand for potato is rapidly increasing in both urban and rural centres. This makes potato a crucial crop which requires a particular attention in terms of resources and long-term planning. However, the potato farmers are unable to increase production and meet the market demand. Potato yield remains low as a result of farmers' limited ability to source inputs, access certified seeds, pay for labour and other production costs. Though many people live of agriculture activities, financial institutions and commercial banks have demonstrated no interest in lending to smallholder farmers due to insufficient collateral, asymmetric information and high transaction costs. This results in mistrust of lenders along the entire value chain and poor accessibility to financing services. Additionally, potato farmers default on benefiting from the huge potential of increased returns from potato markets. The rapid changes in agrifood chain have created domestic and international market opportunities for farmers with the potential of improving productivity and income growth. However, smallholder farmers remain limited to access to markets due to various factors including, price volatility, inadequate information and high transaction costs which force them to sell their produce at low farm gate prices. Unorganized marketing systems, high exploitation by middlemen, collusion between traders, to name but few, prevent smallholder potato farmers from accessing to markets and benefiting from the market prices. Little empirical attention has been focused on financial sustainability of the chain to increase productivity and access to potato markets. However, the sustainability of the chain and adaptability to changing opportunities in the potato market require significant investments. Poor access to finance along the chain constitute the impediments to productivity and quality products which result in reduced market, limited sales returns and limited reinvestment capabilities for all the value chain actors particularly smallholder potato farmers. Therefore, the key problem is to know how the appropriate amount of investment can be obtained for farmers to boost potato productivity as well as increase access to potato markets. Taking smallholder potato farmers in Musanze and Nyabihu as case studies, this study gave insights on extent to which value chain financing would increase potato productivity and increase smallholder farmers' access potato markets in order to raise incomes and improve their livelihood.

1.3 Objectives of the study

1.3.1 General objective

This study is intended to contribute towards increased potato productivity and improved potato marketing through effective access and use of agricultural value chain financing for enhancing the smallholder farm households' livelihoods in Rwanda.

1.3.2 Specific objectives

The specific objectives were:

i. To determine the factors that influencing potato farm household's participation in agricultural value chain financing in Rwanda.
ii. To evaluate the effects of agricultural value chain financing on smallholder potato productivity in Rwanda.
iii. To determine the factors influencing smallholder potato farm households' access to markets in Rwanda.
iv. To determine the factors influencing smallholder potato farmers' choice of potato market outlets in Rwanda.
v. To evaluate the effects of agricultural value chain financing on smallholder potato farm households' livelihood in Rwanda

1.4 Research Questions

The following questions were used to achieve the objectives of this study:

i. What are the main factors that influence smallholder potato farmers' decision to participate in the agricultural value chain financing approaches in Rwanda?
ii. How does agricultural value chain financing affect potato productivity in Rwanda?
iii. What are the main factors that influence smallholder potato farmers' access to market in Rwanda?
iv. What are the main factors that influence smallholder potato farmers' choice to sell to potato market outlets in Rwanda?
v. What are the effects of agricultural value chain financing on the livelihood of smallholder potato farm households in Rwanda?

1.5 Justification of the Study

Potato is the second most important food crop which generates income and contributes more to food security and poverty reduction in Rwanda. Theoretically, increasing productivity of potato production would require either to increase input use, acreage expansion, and efficient use of resources or adoption of new technologies. However, the investments in potato crop would diversify the production of food crops, improve the nutritional diet and help to attain the country's resilience in food production.

Without effective agricultural financing, farmers would not be able to cover production costs, access to market information, supply quality products and hence remain unprofitable from the available market opportunities. This study is very significant to farmers, private sector and other potato stakeholders to streamline the potato value chain and transform it into a vibrant commercialized sub-sector that increases income and improve livelihood of smallholder farm households in Rwanda. Furthermore, the findings from this study will inform the government to develop policies and regulatory frameworks necessary for fostering financing the agricultural sector particularly the potato value chain, to increase productivity, eliminate the market distortions and improve market linkages among value chain actors. Finally, the study was expected to enrich to the scientific body of knowledge of the imperative of the application of the Value Chain Financing Approach as financing strategies for smallholder potato farmers and rapid development of agricultural value chain in Rwanda. This study determined the factors influencing value chain financing and the effects of value chain financing in increasing potato productivity. As a result, this would increase farmers' access to potato markets, raise incomes, and then enhance their livelihood. Furthermore, the study is useful in attainment of SDGs, goal one (no poverty) and goal two (zero hunger).

1.6 Scope and Limitation of the Study

The study was carried out in NorthWest Volcanic zone and did not cover all potato farmers in Rwanda. The study only focused on potato farmers in Musanze district (Northern Province) and Nyabihu district (Western province) as the major potato producing areas in Rwanda. Though the agricultural value chain financing has an impact on productivity and marketing of many of the chain actors, this study focused on the situations of smallholder potato farm households in the chain. Besides, the study did not exhaustively cover all potato farmers of both districts rather it targeted farmers from six sectors and results were generalized to other farmers with assumptions that all smallholder potato farmers operate

under the same financial constraints. During the data collection period (August to December 2019), the researcher faced challenges of interviewing 585 smallholder farmers with no English background at all. The questionnaire prepared in English language was translated into local language (Kinyarwanda) and eleven local enumerators (five enumerators from each district and one co-supervisor) were trained prior to data collection.

1.7 Operational Definitions of key Terms

Agricultural Productivity: this concept refers to the overall efficiency and effectiveness of productive units or a ratio of output to inputs used (Kg/Ha). This is also someone's ability to produce more economically and efficiently (Mohammad, 1992). In this study, agricultural productivity is defined as the ratio of output to inputs such as fertilizers, improved seeds, labour, and technology, all of which are used in agriculture.

Market access: this concept refers to farmers' abilities to sell their products in cross border's markets. It also refers how ease the farmers acquire farm inputs, farm credit and reach the target customers. This study emphasised on walking time, available infrastructure, and distance to markets and access to market information.

Production: Process that involves allocation of land to potato farming and use of inputs and performance of farm level activities to produce potato output.

Smallholder farm household: this is any farm household with limited productive resources whose annual output is equal to or only slightly above the subsistence needs. It mostly produces on farm that is less than one hectare of land.

Value chain: this is a series of value-added activities that involved in bringing a product from production to the end-user/consumer. In agricultural businesses, this can be assumed to be a "farm-to-fork" series of inputs, production, and processing and marketing farm produce to end users.

Value chain actors: Input suppliers, Producers/Farmers, Processors, Traders, consumers, organizations, institutions, government and service providers and involved in potato value chain activities. The relationships between these actors ensure production, marketing, and consumption of potato products.

Value chain analysis: Assessment of the actors and factors that influence the industry's performance as well as the relationships between participants in order to identify the main

limitations to the improved productivity, efficiency, and competitiveness of an industry and how these limitations can be eliminated (Putro *et al*., 2022).

Value chain finance: Financial services and products flowing to and/or through value chain participants to address and alleviate constraints to growth (Putro *et al*., 2022).

Agricultural value chain financing: this refers to a structured way of financing stakeholders operating within the agriculture value chain to reduce risks associated with financing agricultural activities. The study emphasized on how smallholder farmers participated in agriculture value chain financing to increase productivity and access potato markets.

1.8. Outline of the study

This study is organized into the following five chapters:

Chapter one presents the background information of the study, statement of problem, objectives of the study, research questions, justification of the study, scope and limitation of the study and operational definitions of the key terms. Chapter two presents the literature review on concepts relating to agricultural value chain, agricultural value chain Financing, importance and constraints of accessing to agricultural finance on productivity and market access. The chapter also describes potato production and potato marketing in Rwanda and presents the theoretical framework and a conceptual framework of the study. Chapter three describes the methodology adopted to select study area and to collect the data used in the study. The chapter also characterises the target population, describes methods for testing the validity and reliability and methods for data analysis. Results and discussions of the findings are presented in chapter four. Chapter five draws the conclusions and recommendations for the study.

CHAPTER TWO
LITERATURE REVIEW

This chapter aims at reviewing the relevant literature on agricultural value chain, financing agriculture through value chain framework, agricultural value chain financing for productivity and market access, financing models in agricultural value chain, financing smallholder farmers in Rwanda, challenges of financing potato value chain in Rwanda as well as potato production and marketing. Also, this section discussed the theoretical and conceptual framework used in this study.

2.1 Agricultural Value Chain

Porter's define value chain as the activities that organizations perform to deliver value, such as organizational competitive position (Porter, 2008). Further definitions describe value chain as an idea of actors (public and private, including services providers) connected along the chain and undertaking a series of activities including production, transformation, marketing and distribution to bring a product or a service ultimately responds to consumer demand (Henriksen *et al.*, 2010). The main objective of a value chain is to produce value-added products and services for specific markets through transformation of the available resources or use of infrastructures within the institutional environment (ADB, 2012). In agriculture, value chains are therefore viewed as organized linkages between groups of producers, traders, processors, and services providers that come together to boost productivity and added value of activities. Nevertheless, the limitations of each single actor in the chain can be overcome by establishing the synergies and governance rules aimed at producing at higher value.

Subsequently, the term value chain is extended to agriculture for development purposes and is used to describe the flow of physical inputs and services in the production of final product and in terms of its concerned quantitative and technical relationships (Devaux *et al.*, 2018). Agriculture value chain encompasses the flow of products, knowledge and information between producers and consumers. They offer the possibility of capturing added value at each stage of the production, marketing and consumption process. The farm households need to be better engaged with value chains in order to obtain added value for improving the household members' livelihoods while reducing their risks and increasing their resilience (Conway *et al.*, 2014; Vogel *et al.*, 2020). According to Strohm and Hoeffler (2006), agricultural value chains link urban consumption to rural production, changing

demand as consequence of urbanization, emergence of modern consumption patterns or new trends in international trade, effects on rural areas along the value chains and extends over to marketing and production systems. Agricultural value chains also offer growth opportunities to markets in which farmers should gain a comparative advantage. To meet increasing urban demand for food, agricultural value chains must be upgraded, deepened, and expanded. In return, farmers unhappy of the time and effort not well rewarded, should be financially assisted by the market to cut off major or minor risks and create an environment that ensures an agricultural productivity growth (Ruete, 2015).

2.2 Financing Agriculture through Value Chain Framework

The Food and Agricultural Organization of United Nations (FAO) has recommended the development of an integrated value chains as an comprehensive and appropriate strategy for farmers for accessing to finance and to increase of income of agricultural producers through value chain linkages (FAO, 2012). The value chain approach is beneficial to smallholder farmers in linking them to financial markets. Thus, the flow of funds throughout the various agricultural chain actors is known as agricultural value chain financing (Orwothwun & Qutieshat, 2022).

Basically, the value chain financing comprises two approaches: financial sector approach and the value chain approach. The financial sector approach emphasizes on the important role of financial institutions in facilitating access to a broad range of financial services by value chain actors while the value chain approach emphasizes on how value chain actors (input suppliers, processors, intermediaries and buyers) can improve their access to financial services. This takes production chain as starting point and emphasizes on finances supplied to different actors within the agricultural value chain (Huang *et al.,* 2022). The value chain actors add value and improve the efficiency on agriculture from inputs to final product delivered to consumer. It refers to any or all of banking and financial products and support services that flow to/and or through a value chain in order to address the needs and limitations of those involved in the agricultural value chain (Putro *et al.,* 2022). It also serves as the means of enhancing the efficiency and quality of agricultural value chains financing by identifying the financing need to strengthen the chain, customizing the financial products to meet the needs of the participants in the chain; reducing the economic transaction costs through the direct discounting of loan payments including using value chain linkages to mitigate the risks inheriting in the chain (Barling *et al.*, 2022). Financing the agriculture

through value chain is profitable to both lending institutions and farmers. The more the two approaches are connected, the more benefit from each other. A comprehensive value chain linking farmers, banks and the other actors in chain helps to identify the point at which finance might be applied while minimizing the risk to bank or investor (Bai & Jia, 2022). If wisely implemented, it reduces the worries of asymmetric information and transaction costs. Agricultural value chain financing encompasses two forms of value chain financing: Internal value chain financing and external value chain financing.

2.2.1 Internal Value Chain Financing

Internal value chain financing is financing that occurs between parties within the chain. It is provided by the actors in the chain that have a stake in the output or in the produce and therefore provide financing to producers for required expenses such as production inputs, the supplier products sold to a farmer, funds advance from a lead firm to a farmer, trade credit provided by producers to traders or by small to medium scale traders to large scale traders or processors (Figure 1.1). However, internal value chain financing has limited potential for growth and expansion of the value chain and its participants as far as it is more constrained by access to a larger pool of financial resources from outside the chain.

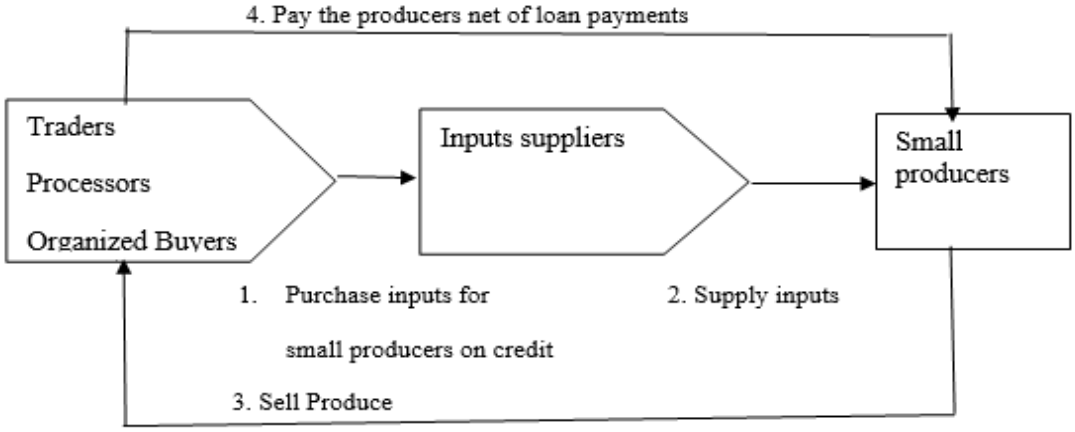

Figure 2. 1: Internal value chain financing

Source: Paguia *et al.* (2008)

2.2.2 External Value Chain Financing

External value chain financing is financing that takes place outside the chain. It is based on value chain relationship and mechanisms between financial intermediaries and other players in agricultural value chain (Figure 2.2). Bank loans may be issued to farmers either through contract with a trusted buyer or through warehouse receipt of recognized storage

facility. These transactions are often made possible as a result of integrity of relationships between various players in the chain and extent to which links reduce default or non-performance risk (Barling *et al*., 2022).

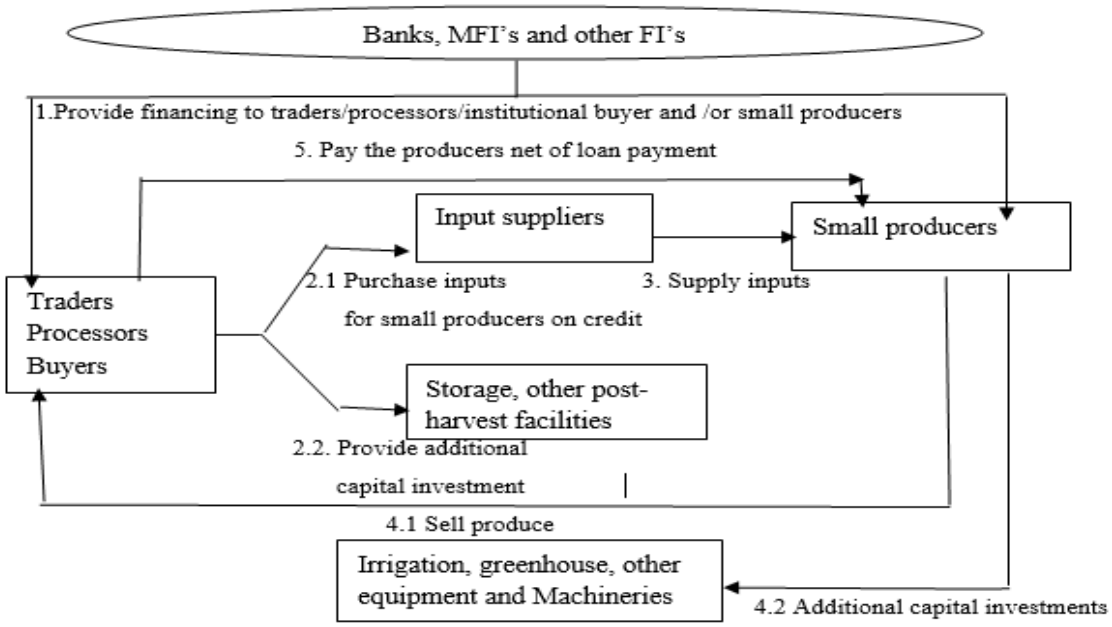

Figure 2. 2: External value chain financing

Source: Paguia *et al.*(2008)

2.3 Agricultural Value Chain Financing for Productivity and Market Access

Farmers and other value chain actors only contribute to food security since they improve the productivity and increase their incomes. This is based on production function analysis which considers capital and labour as factors which the productivity is focused. To meet the market demands, farmers need to invest more in modern production practices, including use of new technologies and access to better inputs.

2.3.1 Agricultural value chain financing for agricultural productivity

According to literature, access to financing has been noted as critical challenge for farmers to increase productivity. Value chain financing approach is an innovative approach to bridge the financing gap of these farmers (Ojo & Ayanwale, 2019). Agricultural value chain financing is comprehensive approach that looks beyond direct borrowers to their linkages in order to access to a series of financial instruments that can be used for agricultural and agribusiness financing, facilitate improved financial services, and lower farmer agricultural and financial costs (ADB, 2012). The persistent case of low productivity resulting in low

income and saving capacity could only be offset when farmer is guaranteed access to credit facility (Owusu, 2017).

Many studies have found the positive influence of credit facility to farmers' activities. In their study on access to credit and its impact on Welfare in Malawi, Diagne and Zeller (2001) have found that agricultural financing had a significant positive impact on agricultural productivity as it enabled farmers to acquire the necessary inputs such as improved seeds, fertilizers and labour in order to raise the productivity of farmers. This has also been confirmed by Duy (2015) in his research on the role of access to credit in rice production efficiency of rural households in the Mekong Delta, Vietnam. His study has concluded that technical efficiency and rice yield were positively influenced by accessed to credit, education and technology, and access to formal credit sector had a lager effect on rice production than access to informal credit. Parvadavardini and Nagarajan (2015) have also demonstrated a positive impact of agricultural financing on the farmer's productivity through a sustainable use of extension practices.

In the study of value chain financing and plantain production in Nigeria, Ojo and Ayanwale (2019) found also a positive impact value chain financing measured in terms of increased net present value and net benefit to plantain farmers. Adequate agricultural value chain financing facilitates farmers to make better allowances to risks associated with the nature of the agricultural production undertaking and enable to afford large investments. AVCF offers opportunity to expand financing for agriculture, improve efficiency and repayments in financing and strengthen or consolidate linkages among the participants in the chains. Nzomo and Muturi (2010) in Kenya, Nosiru (2010) in Nigeria, Girabi and Mwakaje (2013) in Tanzania, and Baffoe and Matsuda (2015) in Ghana confirmed the potentials of agricultural financing access to improve productivity for credit participants than non-credit participants.

2.3.2 Agricultural value chain financing for market access

The issue concerning linking farmers to markets is prominently a global challenge. Agricultural value chain is aimed at improving the quality of agriculture products, it also aims at producing value added products or services for a market by transforming resources and by the use of infrastructures (Trienekens, 2011). The contribution of smallholder farmers to food security and poverty alleviation battles in developing countries are largely influenced by their continued access to markets (Wiggins & Keats, 2013). Therefore, linking them to markets creates the necessary demand, offers remunerative prices and increases smallholder

incentives. These incentives are as a result of better market access leading to increase production and adoption of modern production techniques and post-handling practices. This implies that linking farmers to markets can boost the productivity and income growth that in turn improves the smallholder farmers' livelihoods and overall country's economic growth (Markelova & Mwangi, 2010). However, inadequate storage facilities, poor contact with the market, insufficient information on prices, poor technologies, high transaction costs and credit constraints (ADB, 2012; Shiferaw *et al*., 2008) make difficult to farmers to take advantages of market opportunities and sell their produce immediately at harvest at lower prices.

Farmers clearly need not only an increase in productivity but also to be effectively linked with profitable markets, which requires valuable investments. The value chain finance is solution for the severe constraints of smallholder farmers to operate in the value chain that include inadequate technical knowledge or absence of attractive market (KIT & IIRR, 2010). In value chain financing, financial institutions engage with the actors in the chain and create a triangle of cooperation between the producer, the buyer and financial institution. Agriculture sector plays a great role in reducing poverty as far as farmers are empowered to gain market power and able to deliver their produce to domestic, regional or international markets.

Therefore, in this study, market access has been studied in cases of market participation model whereby farmer may decide to sell or not and the amount to sell. The value chain finance is here regarded as financing framework that aimed at linking farmers to participate to markets (Mcmichael, 2013). Strengthening the abilities of farmers to access to markets reduce the inefficiencies, increase productivity, improve their connection with buyers and become more profitable than they would ever have conceived.

2.4 Financing models in agriculture value chain

The nature of agriculture provides ways of mitigating the above risks through use of agricultural value chain finance to accomplish risks assessment and monitoring them. Rather than relying on the creditworthiness of individual farmers, agricultural value chain financing relies on business relationships in the value chain. Due to this, many forms of financing models have emerged to overcome the challenges and reduce the risks and costs of agricultural lending.

2.4.1 Contract farming or Outgrowing Financing

Smallholder farmers face problems in production and marketing their produce and decide to sell it to middlemen and brokers at relatively low farm gate price. This has impacts on low

returns to smallholder farmers irrespective to the production and marketing costs. Contract farming assumes extensive number of arrangements along the value chain to link smallholder farmers to marketing partners by stipulating terms of mutual liabilities with formal or informal contract (Strohm & Hoeffler, 2006). Contracting between farmers, processors or other marketing actors in the value chain are some of the strategies for smallholder farmers to be linked to higher end markets, receive higher returns (Barrett *et al.*, 2012), reduce the transaction costs and minimize the risks of overexploitation of middlemen in the agro business chain (Bijman, 2008). Under contract farming, farmers and the value chain actors including processors, marketing firms and traders are bound for the production and supply of agricultural products under forward agreements, frequently and at predetermined prices (Eaton & Shepherd, 2001).

Setboonsarng *et al.* (2008) have studied Rice contract farming in the Lao People's Democratic Republic, using data collected from 332 contract farmers and 253 non-contract farmers, and have discovered that contract farmers earn significantly higher profits than non-contract farmers. Strohm and Hoeffler (2006) investigated the factors that impact on contract farming in Kenya using case studies of French beans and other horticultural export crops, mangoes and other fruits, passion fruits, potato and poultry. They have found that contract farming improves the wellbeing of the farmers. However, the contract farming become a challenge to farmers who violate the contract and not sell their crop to market as stipulated into contracts or when marketing firms fail to collect the products from farmers after harvest.

Nonetheless, farmers cannot produce unless they know they are able to sell their crop, traders or processors cannot invest in ventures unless they are assured that the required commodities can be consistently produced. Purchasing and selling on a contractual basis provides the smallholder farmers with market guarantees while also insuring supply to other chain players (Al-Hassan *et al.*, 2006). In agriculture this contact serves both for market access and ease access to credit (Baumann, 2000). Contract farmer financing is also a binding arrangement among banks and agricultural chain actors (processors, aggregators and traders) through which a farmer or a group of farmers are enabled to acquire financing from banks backed by the value chain actors' guarantee in returns of assured supply of quantities and quality of agricultural produce as per stipulated in the contract (SBP, 2014).

2.4.2 Trade credit financing

Dary (2017) defines trade credit as a type of short-term financing used by non-financial firms in the inter-firm business. When a company sells goods or services to customers on credit, it is equated to accounts receivable, when a company buys inputs from a supplier on credit; it is equated to accounts payables. The common form of trade credit is prepayments or advancement payment where payment precedes the delivery of goods. Traders finance producers who repay, usually in kind, at harvest. This allows traders to procure products and provides farmers with the needed cash as well as a guaranteed sale of outputs (Parvadavardini & Nagarajan, 2015).

In agricultural businesses, the trade credit financing can be in form of inputs provided to farmers in kind or in cash advances from input suppliers, intermediary traders and shops, or agro-processors pledging to repay from the future harvest income (Manen *et al.*, 2012). As financial institutions are reluctant to lend to smallholder farmers, the later turn to very expensive informal credit sources to finance their working capital needs. This gap between commercial bank and farmers may be bridge to buyer and supplier trade credit agreement (Coates & Hofmeister, 2013). The buyers and suppliers offer credit to farmers as part of inputs supply or product purchase transactions (Pearce, 2003). However, these transactions do not directly involve a bank, and the agreement is usually informal and based on trust. In Philippines, most of inputs traders advance rice seeds to farmers for production, expecting to be repaid after the harvest (Shepherd, 2004). However, both processors and wholesalers may lend to traders who regularly buy from farmers and these in turn may lend to farmers. Wholesalers and processors also may lend in opposite direction to distributors and retailers (Pearce, 2003). Moreover, processors and financial institutions can also act in partnership to extend credit to farmers into cooperatives who repay after harvest. The trade credit financing serves as good process to secure supply, guarantee markets and reduce transaction costs in agricultural marketing. It serves also an easiest and most important short-term source of finance available in agribusiness. However, trade credit limits the bargaining power of smallholder farmers as they depend on the credit for their production activity (Gouri & Mahajan, 2017).

2.4.3 Input supplier financing

Access to and use of agricultural inputs like certified seeds, fertilizers and pesticides, is a key to increase agricultural productivity. These inputs are extremely expensive to farmers and

commercial banks willingly complicate the lending process to them. Consequently, farmers incur risks of underinvestment in production and thereby receiving low yields and low incomes. Input supply financing is of the ways of addressing this challenge through access to inputs such as seeds, fertilizers and pesticides problems to increase productivity. Input supply financing involves the financing of farmers' activities by other value chain actors who have access to bank loans (Konlambigue, 2007). Under this process, input suppliers advance fertilizers, certified seeds, pesticides and equipment to the farmers who accept to repay at harvest period or any mutually agreed time the farmers have liquidity. Though input supply does not address the market access like the above models, it stimulates farmers to provide quality produce to market.

2.4.4 Warehouse receipts financing/Inventory credit

The biggest constraint for farmers to improve farm productivity and improve their livelihood is inadequate collateral to be eligible for loans from formal financial institutions. However, warehouse receipts system can provide hope to farmers to access to and use financial services and other services that facilitate production without requiring physical collateral delivery. Warehouse receipts financing is a form of collateralized commodity transaction where the commodities stored in licensed warehouse secure the depositor to access bank loans (KMP, 2013). The lending institutions provide financing to a depositor against the security of commodities in a controlled warehouse. The inventory (warehouse) used as guarantee for obtaining finance is backed by a receipt, hence the term "warehouse receipts financing"(Winn *et al.*, 2009). The warehouse receipts are issued by a warehouse operator as evidence of specified commodities of certified quantity and quality of stored commodities at particular location by named depositors to whom the receipts are issued. The depositor may be an individual farmer, farmer group, traders or processors.

However, the warehouse operator holds in safe custody the commodities but does not take the ownership. The latter is liable for the loss due to theft or damage by fire and other catastrophes which makes availability of insurance or underwriting services. In agricultural value chain, this arrangement is an efficient and effective tool for smallholder farmers, not only to benefit from an ease access to loans, but also to negotiate better prices as a block (EAFF, 2013). Farmers keep safely their produce, minimize post-harvest losses, maximize the value and strengthen their opportunities for a collective bargaining. Farmers have more flexibility in timing the sale to benefit from a seasonal price increase. They are free to decide

whether to sell immediately after harvest, when the prices are still low or store in a registered warehouse and apply for a short-term credit, when the prices may go up. Warehouse receipts financing model decreases financial tress experienced before and stimulates establishment of marketing cooperatives. On the other hand, warehouse receipts financing model facilitates commercial banks to minimize its risks of loaning to small scale farmers through provision of credit against goods and liquid collaterals. Nonetheless, perishability of products, inadequate good storage facilities, limited collateral, management skills, poor quality of products stored at sell, lead to the impracticable for products to secure enough to mitigated risks.

2.5. Financing smallholder farmers in Rwanda

According to Reyes *et al*.(2012) and Pham and Lensink (2007), agricultural sector rely on formal, semi formal and informal lending institutions. Formal lending institutions includes private and public commercial banks and micro-financing institutions. They provide credit facilties for large scale farmers and well of clientele which satifiy their stringent loan conditions. Informal lending institutions consist of private money lenders, relatives, rotating savings and credit associations (ROSCAs) and other individuals (Pham & Lensink, 2007). However, due to the constraints in obtaining credit from formal lending sources, smallholder farmer mostly obtain credit from the informal credit sources which charge higher interest rates and less capitalised. Semi formal institututions includes saving and credit cooperatives, international organizationa and non government organizations. The semi formal instittutions could form a bridge between the formal and informal sectors. They provide credit facilities for cooperatives, poverty alleviation program, job creation program and for other programs. However, in order to have a big change in improvemnt in household's economic security, creation of future socio-economic opportunites, access to financing opportunities is inevitable (Green *et al.*, 2006).

The Rwanda's financial sector consists of 504 institutions spread across the country including 17 banks, 16 insurance companies, 470 microfinance institutions (Sectors' SACCO's), 1 development bank and 1 pension fund (AFR&IPAR, 2018). However, like in any other undeveloped countries, smallholder farm households face limited access to financing whether in production and marketing and this affect negatively productivity and access to market. Farmers are victims of low commercial bank lending (Oberholster *et al.*, 2015) which explains limited substantial capital required to cater for production and market risks. The commercial banks set very demanding conditions which lock them to access loans.

Ignoring the conditions in which farmers operate, once credit demands accepted banks delay to disburse the money and often charged at high interest rates of between 18-20 %, which makes cost of borrowing extremely higher to smallholder farmers (Janssens *et al.*, 2013; Muhinyuza *et al.*, 2012) and thus impact negatively on their agricultural activities.

2.6 Constraints for accessing to agricultural finance and its impact on productivity

Farmers' access to and efficient utilization of credit is very vital in increasing farm productivity, increasing household incomes and improving livelihoods. However, while a lot of progress has been made in easing credit access, there are still limiting factors to access to appropriate agricultural financing products (EAFF, 2013). In addition, the institutional supply of agricultural finance remains insufficient, which hampers technology transfer and investment into agriculture (Olagunji & Ajiboye, 2010). In their studies Temu (2009) and Manen *et al.* (2012) have identified high transactions costs (inaccessibility of rural areas and physical access challenges, asymmetric information, underdeveloped infrastructure), low income cash flows and inadequate collateral, social cultural barriers, demand for small volumes savings, demand for small loan sizes, highly risky commodity and financial markets, weak collaboration among farmers, inadequate banking technology, and government interference as key constraints for farmers to access to agricultural finance. Gashayie and Manjit (2015) and Miller (2004) have summarized these constraints into four broad groups (Table 2.2).

Moreover, while banks are more concerned about the interest rate they receive on loan and riskiness of that loan, farmers are subjected to high bank restrictions which results in smaller loans or rejection for credit at all. Farmers face the consequences of credit rationing (Dohcheva, 2009). Credit rationing can occur among some loan applicants with the same identity and some receiving loans while some others do not receive. Even if the rejected applicants would have pay higher interest rates; or among easily recognizable groups of people who, with a given credit supply, cannot get loans at any interest rate, despite the fact that they would get loans at larger credit supply (Reyes *et al.*, 2012). Due to such credit restrictions, famers face notorious credit markets imperfections. The effects of imperfect credit market coupled with quasi absence of insurance measures for coping with agricultural risks are summarized into inefficiency and low productivity, downstream slope of gross value added, slow adoption of new technologies, low investments and slow development of agricultural sector (Dohcheva, 2009).

Table 2. 1: Types of agricultural finance constraints and their specific issues

Category of constraints	Types of constraints	Issues
1.Vulnerability constraints	Systemic risk	Weather
	Market risk	Plagues, diseases
	Credit / financial risks	Price fluctuation
		Production
		Useable collateral
		Demand preferences
		Health & family needs
2. Operational constraints due to	Low investment returns	Low growth potential
	Low investment and asset levels	Low velocity of capital
		Non-competitive technologies
	Low geographical dispersions	Inadequate market integration
		Poor quality of roads and communication
		Low efficiencies of business operations
		High operating costs
3. Capacity constraints	Infrastructural capacity	Poor business investment
	Technical capacity and training	Inadequate competitive technologies
		Poor roads
	Social exclusion	Inadequate communication
	Institutional competency	Poor education system
		Poor technical and management skills
		Inadequate social representation (cultural, linguistic, and civil society)
		Inadequate institutional capacity
4. Political and regulatory constraints	Political and social interference	Political interference
		NGO “donation” interference
	Regulatory framework	Cultural and gender constraints
		Land tenure laws
		Financial regulations
		Tax policy

Source: Gashayie and Manjit (2015); Miller (2004)

It can therefore be reiterated that there is a need for new and innovative agricultural financing solutions that are commercially viable for both financial institutions and smallholder farmers as solution.

On my view, value chain financing is found as solution to mitigate the risks in agricultural investment by investments in production and increasing market access using financial instruments. Usually, the financial instruments ensure farmers to increase their productivity and manage risks. If they are lacking or not meeting the farmer' needs, farmers may be discouraged to make any decisions of investing into agricultural businesses. However, this study is focused on the first three categories of constraints, vulnerable constraints, operational constraints, and capacity constraints that hinder farmers' activities in potato value chain.

2.7 Potato production and potato marketing in Rwanda

2.7.1 Potato production

Potato was introduced in Rwanda by German soldiers and Belgium missionaries in early 20th century. It is the country's second most important staple food after Maize (Nelson *et al.*, 2016). Though potato is cultivated across the country, four districts Burera, Musanze, Nyabihu and Rubavu are the most producing districts and responsible of over 60 % of the national production (FAO, 2016; Mugabo *et al.*, 2018) where the crop is grown year round and harvested three times a year. In Rwanda , the national average yield of potatoes is between 10 and 11 metric tons per hectare which is lower than 30 to 40 metric tons per hectare attainable by research stations (NISR, 2015). Table 2 depicts the area cultivated, production and productivity of potato in Rwanda (2000-2017).

Table 2. 2: Area cultivated, production and productivity of potato in Rwanda (2000-2017)

Year	Area (Ha)	Production (Tons)	Productivity (Ton/Ha)
2000	108,983	957,202	8.78
2001	117,403	1,012,269	8.62
2002	124,972	1,038,931	8.31
2003	133,954	1,099,549	8.21
2004	133,418	1,072,770	8.04
2005	135,622	1,314,050	9.69
2006	139,043	1,275,585	9.17
2007	124,621	967,283	7.76
2008	127,226	1,161,943	9.13
2009	126,167	1,289,623	10.22
2010	150,777	1,789,404	11.87
2011	130,000	1,171,500	9.01
2012	120,000	1,337,700	11.15
2013	95,000	1,240,700	9.86
2014	62,156	719,006	11.57
2015	75,342	742,626	9.86
2016	106,236	751,284	7.07
2017	93,991	846,184	9.00
Average	**123,818**	**1,163,977**	**10.03**

Source: Rwanda Agriculture and Animal Resources Board (RAB) (2019)

However, this low productivity is relatively attributed to poor agricultural practices, including limited access to quality seeds, low application of fertilizers, high vulnerability to pests and deseases heavily associated to weather and climate conditions, generally beyond the farmers' control (CIP, 2011; NISR, 2010). Figure 2.3 shows the potato production and area under cultivation in Rwanda from 2000-2017; Figure 2.4 shows the potato productivity and area under cultivation (Tons/Ha) in Rwanda from 2000-2017.

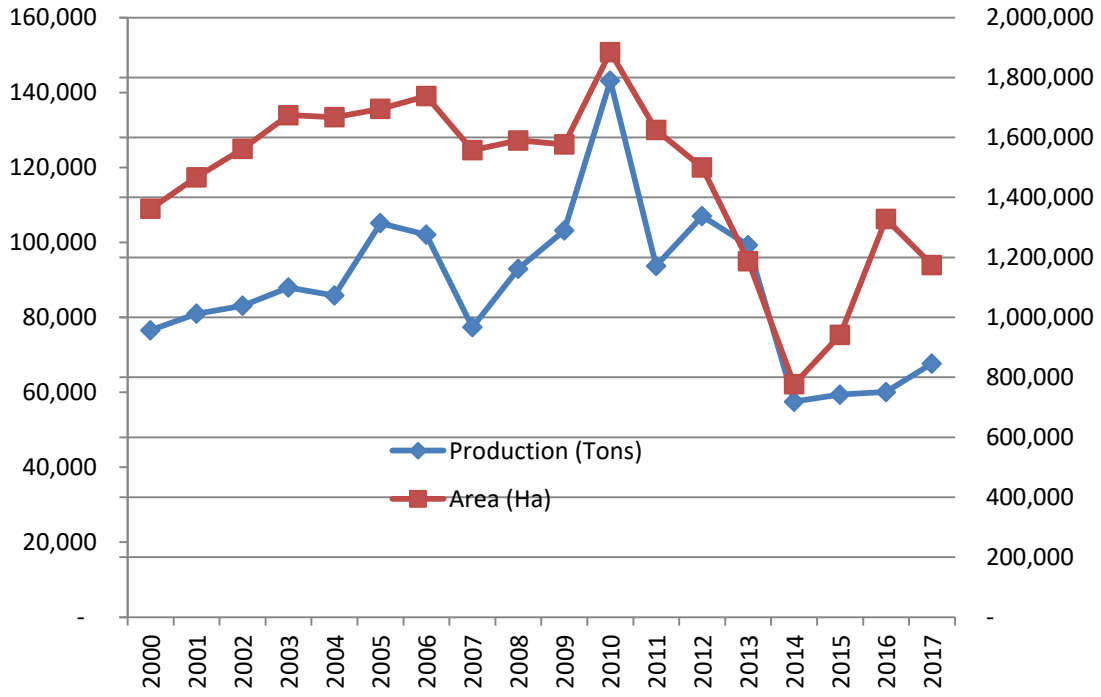

Figure 2.3:Potato production (Tons) Vs Area under cultivation (Ha) in Rwanda from 2000-2017

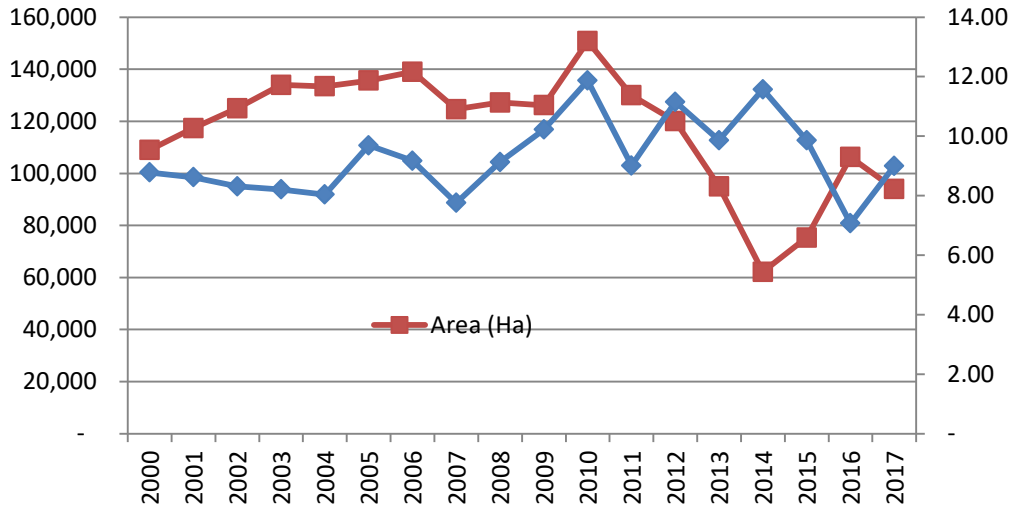

Figure 2.4: Potato productivity 2000-2017 (Tons/Ha) vs Area under cultivation (Ha) in Rwanda from 2000-2017

2.7.2 Potato Marketing

African countries, including Rwanda are undergoing significant agricultural transformations for achieving the SDG's. Particularly in Rwanda, improving productivity of agriculture is paramount for income generation and rural transformation (MINECOFIN, 2013). Facing sharply increased food demand and consumption habits driven by demographic factors, the country vision is to shift from largely subsistence- based agriculture to niche- market and buyer-driven agriculture (MINECOFIN, 2013). The best strategy to achieve this vision was to increase agricultural productivity and increase smallholder farm households' access to agricultural market (GoR, 2013). However, this process is driven by increased investment which occurs in presence of massive marketing opportunities (Martey *et al.*, 2012). Farmers have no incentive of making such investments in areas where there are no opportunities for participating to markets as key for agricultural transformation. Recent studies have shown that increased market participation enables farmers to increase agricultural productivity, generate income and improve food from market and buyer driven agriculture (Abu, 2015). However, many factors still weaken the abilities of farmers to access or participate to agricultural markets. In the study factors limiting and preventing emerging farmers to progress to commercial agricultural farming in the King William's town area of the Eastern Cape Province, South Africa, it was discovered that poor roads, inadequate and insufficient transportation to markets, poor marketing skills and information, poor market infrastructure and high transaction costs being the specific limiting factors which famers face when participating in markets (Khapayi & Celliers, 2016). Furthermore, potato farmers face also a number of constraints to participate to potato markets. These include inability to control over the market and volatility of prices at different times of the year depending on the relative abundance or scarcity of potato in the market which impact negatively on the expected gross revenues (Brenneis & Fortenbacher, 2016) . In addition, high-value crops and perishability linked with high operational costs, costs of transportation and inefficient cold facilities are listed among the barriers for smallholder farmers' access markets (Pingali *et al.,* 2005). In this regard, the Rwandan government launched a potato marketing model through collection centres operations to improve the potato distribution system but farmers and consumers continued to complain about the limited access to markets highly dominated by middlemen and the collusion of traders who dictate the prices (Afadhali, 2018). To contribute to bridge the knowledge gap in the available literature, this study has determined the relevance of the use agricultural value

chain financing to increase potato productivity and improve market access in Rwanda particularly in Musanze and Nyabihu Districts.

2.8 Theoretical framework

This study focused on effects of agricultural value chain financing on potato productivity and market access on farm households' livelihood . It was conceptualized on theories of agricultural production function , random utility theory and agricultural household models.

2.8.1 Agricultural production function model

Agricultural production theory explains the relationship between inputs such as capital, labour and land and outputs. The theory emphasises on minimizing cost of production and maximising the outputs. When used appropriately, agricultural loan can significantly boost agricultural productivity. It is the prerequisite for any agricultural economic activity as it facilitates the acquisition of production inputs, application of new technology (Isiorhovoja & Chukwuji, 2009), and essential to the maintenance of production efficiency. The vital role of agricultural efficiency in increasing agricultural output has been recognized by many researchers and policy makers while measuring the efficient use of resources to achieve optimum production level (Enenche *et al.,* 2014). The production function is technological relationships between the quantity of resource inputs (land, labour and capital) transformed into production outputs (commodity).

Since the main goal of the study is to assess the effects of agricultural value chine financing on potato productivity, a stochastic frontier analysis is hereby adopted. According to Afriat (1972), the prediction of parameterized functions was assumed to be a function that gives maximum possible output as a function of certain traditional production factors and it is given as:

$Y_i = f(X_i; \beta)$ ……. (2.1)

Where Y(i) is the maximum output obtainable from X_i a vector of inputs, and β an unknown parameter vector to be estimated. However, Aigner and Chu (1968) have suggested the estimation of β by mathematical programming methods based on a cross section of N organizations within a given industry. They have suggested minimization of

$\sum_{i=1}^{n} \lceil Y_i - f(X_i; \beta \rceil$,……...…(2.2)

subject to $Y_i \leqq f(X_i; \beta)$ which is a linear programming problem iff $(X_i; \beta)$ is a linear in β.

Alternatively, they have suggested minimization of subject the same constraints, which is a

$\sum_{i=1}^{n} \lceil Y_i - f(X_i; \beta \rceil$,……..……(2.3)

quadratic programming problem if $f(X_i; \beta)$ is linear.

In order to characterize differences in output among organizations with identical input vectors or to explain how a given organization's output lies below the frontier, f $(X_i; \beta)$, and an error term is implicitly assumed. In order to give a statistical basis, a one-sided disturbance the $\mathcal{E}_i$ is explicitly added to equation (1), which yields the model:

$Y_i = f(X_i; \beta) + \mathcal{E}_i = 1 \ldots\ldots N$ ...(2.4)

Where $\mathcal{E}_i$ is ≤ 0. Given a distribution assumption for the disturbance term, the model can be estimated by maximum likelihood techniques (Aigner *et al.*, 1977).

The error term ε_i in equation (3) is comprised of two components: $\varepsilon_i = \nu_i - \mu_i$, where ν_i is assumed to be independently and identically distributed as $\nu \sim N(0, \sigma_\nu^2)$ random error and represents random variability in production that cannot be influenced by producer, μ_i is a non-negative random variable associated with technical efficiency in production and is assumed to be an independently and identically distributed as half-normal, $\mu \sim N(0, \sigma_\mu^2)$ (Greene, 2008). This specifies the relationship between output and input levels using two error terms. The production frontier measures the maximum potential output for a given input vector, X_i. Both ν_i and μ_i cause actual production to deviate from the frontier. ν_i is a two-sided random error component beyond the control of farmer; μ_i is a one-sided inefficient component. Inefficiency levels are determined by the two terms in the maximum likelihood estimation of the production function. The stochastic frontier function therefore becomes:

$Y_i = f(X_i; \beta) + \mathcal{E}_i = f(X_i; \beta) + (\nu_i - u_i)$ ……..……(2.5)

where Y_i is the production level (output) of the i^{th} farm; f $(X_i; \beta)$ is a suitable function; X is a vector of inputs of i^{th} farm; β is a vector of parameters that represent the output elasticity to be estimated. The function f(.) is typically a Cobb-Douglas production function or translog production technology. The Cobb-Douglas production frontier function is expressed in the following ways (Van Passel *et al.*, 2009):

Cobb-Douglas production function: $\log(Y_i) = \beta_0 + \sum_{k=1}^{n} \beta_k \log(x_{ik}) + v_i - u_i$……(2.6)

Translog production function:

$$\log(Yi) = \beta_0 + \sum_{k=1}^{n} \beta_k \log(x_{ik}) + \sum_{k=1}^{n} \beta_{kk} \log((x_{ik})^2 + \sum_{k=1}^{n} \beta_k \beta_k (\log(x_{ik}).(\log(x_{it})).v_i - u_i \quad (2.7)$$

The Cobb-Douglas production frontier or translog techniques would also be applied to estimate the relationship between outputs and inputs used for potato production (Dutta, 2003). Stochastic frontier production model allows the estimation of the determinants of the technical efficient level in inefficiency model. The variable u_i, which estimates technical

inefficiency of farmer, is regressed against the farmers' socioeconomic characteristics (*S)* with the credit use (*Cr*):

$u_i = \gamma_0 + \sum_{k=1}^{n} \gamma_k S_i, Cr_i$…… .. .(2.8)

The likelihood function is expressed in terms of variance parameters (Battese & Coelli, 1995). The likelihood function and its partial derivatives to parameters of the model are presented as follows:

$\delta^2 \equiv \delta_v^2 + \delta_u^2 \; and \; \gamma \equiv \delta_v^2 . \delta_u^2 = \frac{\delta_u^2}{\delta_v^2 + \delta_u^2}$…… …..(2.9)

2.8.2 Random Utility maximization (RUM)

Potato farmers' choice to access to agricultural loan is anchored on the random utility maximization model (RUM). The model assumes that the decision maker has a full discrimination capability to choose an alternative with the highest utility to maximize their wellbeing. The farmer makes rational choice to maximize utility subject to a set of constraints (Green, 2003). The model postulates that if the costs associated with using a particular alternative are greater that the benefits, households will be discouraged from using it and shifts to another option that maximizes their utility. The individual chooses the alternative that has the maximum utility. The utility function for random utility is defined as

$U_{ki} = \beta^* X_{ki}$……..……....(2.10)

Where,

U_{ki} is the total utility of alternative *i* for individual farmer *k*

β * is the vector of parameters associated with attributes X. Utility is assumed to be a linear in parameters functions of attributes X

X_{ki} is the vector attributes that vary across individuals and alternatives.

However, following the Green (2004), the farmer's decision to use agricultural loan or not depends on unobservable utility which may influence the choice. The farmer must have perfect information. This implies that uncertainty has to be taken into consideration. The utility function is modelled as random variable to account for uncertainty. It is assumed to have two components. The systematic or deterministic component contains the observed variables that describe characteristics of farmer and alternatives. The unobserved or error component is random term that represents the unknown portion of the farmer's utility (Gujarati, 2004) . The utility function is expressed using

$U_{ki} = \beta z_{ki} + \mathcal{E}_{ki}$……..…(2.11)

where

U_{ki} is the total observed utility of alternative *i* for individual farmer *k*

β is the vector of estimates for β*

z_{ki} is the vector of attributes for alternative *i* and individual farmer *k*

$\mathcal{E}_{ki}$ is the unobserved error component.

Potato farmer were confronted with a choice between use agricultural loans and not use agricultural loan. The farmers' decisions to use agricultural loans were expected to be influenced by a set of household socioeconomic and demographic variables. Therefore, individual farmer *k*'s expected utility from the use agricultural loan. The farmer's expected utility of use of agricultural loan or not can be expressed as:

$EU_{ki}=\beta_{ki}z_k+\varepsilon_{ki}$ ……..……...…(2.12)

$EU_{kj}=\beta_{kj}z_k+\mathcal{E}_{kj}$ ……...…….. …….(2.13)

Whereby $EU_{mi}$and EU_{mj} denote the expected utility with use and non-use of agricultural loan respectively, *i* and *j* represent the individual farmer's choices, z represents a set of farmer *k'*s socioeconomic and demographic variables, $\mathcal{E}_{kj}$ represents random disturbance and assumed to be identically and independently distributed with the mean zero. Farmers prefer to use agricultural loan as far as the difference between the expected utility to use and non-use credit is positive. $(EU_{ki} - EU_{kj}) =(\beta_{ki}z_k+\varepsilon_{ki}) - (\beta_{kj} + z_k+\varepsilon_{kj})> 0$ ……. (2.14)

$= (\beta_i-\beta_j)z_k+(\varepsilon_{ki} - \varepsilon_{kj}) = \beta z_k+\varepsilon_k$……..... (2.15)

The difference between use and non-use of agricultural loan is the potential factor that influences farmer's decision (Awotide *et al.,* 2015).However, most of potato farmers are smallholder farmers who generally produce for their home subsistence and sell part of their outputs to pay for the labour. Like other economic agents, farmers have started producing for commercializing their produce, and must maximize a net revenue with respect to levels of products, factors and constraints as determined by the market. This can be expressed as:

Max $\pi = p_a q_a - p_x x - wl, profit$ ……..……..(2.16)

q_a is the quantity of potato the farmer gets from his field.

p_a is the price of potato the farmer gets from the potato market.

x with pricep_x. These include inputs (seeds, fertilizers, pesticides…) expenses, costs for potato transportation and costs of signing contracts with buyers.

l (Labour) with price *w*.

z^q is farm characteristics and fixed factors (farm size and fixed capital).

Therefore, the famers' revenue is the income they get from the sale of potato at given market price. Farmers must reduce the costs incurred in the production and sale of the potato in order to remain with the profit. Inputs $p_x$is a vector of number of inputs like seeds, fertilizers, pesticides and fungicides, harvesting costs, transportation costs, labour costs, to mention but few. These inputs valued at their different market prices are the costs incurred. Therefore, $g(q_a, x, l, z^q)$=0 production function

Supply function: $q_a = q_a(p_a, p_x, w, z^q)$ ……..…...(2.17)

Factor demands: x= x (p_a,p_x, w, z^q) ……..(2.18)

Labour factor: l=l (p_a,p_x, w, z^q) ……..……...(2.19)

Max. Profit: π^*=$\pi^*(p_a, p_x, w, z^q)$…..……...(2.20)

Studies have shown that apart from socioeconomic factors, farmers are also affected by institutional, market, financial and other external factors in deciding on whether or not or not to participate in potato markets (Abdullah *et al.*, 2017; Martey *et al.*, 2012; Reyes *et al.*, 2012). Therefore, a smallholder farmer maximizes profits from the sale of potato produce subject to the constraints he/she faces. This can be represented as:

Max. Profit: π^*= $\pi^*(p_a, x, y, \mathrm{w}, z)$……...…….(2.21)

x= socioeconomic constraints which include farmer characteristics, farm characteristics and farming investment cost

y= institutional constraints which include costumer search costs, availability of market information, selling policies, opportunity cost, cost of contract, membership to farming organizations and institutional standard measurement.

w= financial constraints which include amount of credit, loan requirement, cost of borrowing, annual interest rate, collateral required, capacity to pay back the loan and financial standard measurement.

z= market constraints which include length of supply chain (distant to market), market organisation, quantity demanded, quantity sold and selling price and market standard measurement where:

π=$\beta_j x_j + \beta_k x_k + \beta_n x_n + \beta_m x_m + \cdots + \varepsilon$ ……..…… (2.22)

π=Profitability

x_j=socioeconomic constraints

x_k=institutional constraints

x_n=financial constraints

x_m= market constraints

2.8.3 Agricultural Household model (AHM)

This study applied agricultural household model (AHM) to examine the influence of the farm household behaviour on decision making regarding to the use of agricultural value chain financing approach in potato production and potato marketing. The AHM assumes the existence of perfect markets for goods produced and consumed by farm households. This allows farm households to separate production and consumption decisions to maximize their utility.

The agricultural household model imitated from the standard of agricultural production and demand for goods, was extended to the household decisions relating to child care, crop adoption, education, home production, labour supply, land tenure, nutrition and financial markets (Haddad *et al.*, 1994; Sahn *et al.*, 1994; Strauss & Thomas, 1995). Farm households are the basic unit for interpersonal interaction, generally reflecting both the biological and economic commonalities that promote sharing of consumption and productive resources (Haddad *et al.*, 1994). Furthermore, investment decision in agricultural activities has a long term effect for a farm household's income and consumption patterns (Hill, 2010). According to the literature, agricultural household model (AHM) can be divided into two models: unitary and collective household models (Alderman *et al.*, 1995).

Unitary Model of Household Behaviour

Unitary model generally assumes that the farm household behaves as if it was a single individual and represents unit of decision making. The model assumes that household members' preferences are represented as a single welfare function which reflects the preferences of all its members (Haddad *et al.*, 1994). Another assumption for unitary model is the pooling all farm household resources. The model assumes that all household members share equally the household resources and enjoy the same level of welfare (Europian Commision, 2013; Falkingham, J & Baschieri, 2005). The model treats the households as units of both production and consumption. This implies that all resources (capital, labour and land) are pooled and all expenditures are made out the pooled income (Singh *et al.*, 1986). Certainly, households are both producers and consumers of farming produce. As producer, farm household decide of how much of the resources needed to allocate in production of agricultural goods and services. Also as consumer, it decides how much of the resources to allocate in the consumption of agricultural goods and services to maximize the utility function (Singh *et al.*, 1986). This is called unitary model because describes how

households' decisions related to production and consumption are simultaneously taken by one appropriate decision unit (Browning & Chiappori, 1998; Haddad *et al.*, 1994; I. Singh *et al*., 1986).

Though the unitary model is regarded as a powerful and malleable model to analyse the household decisions, it is criticised for being based only on a single individual. Household members act as if they only have one decision maker (Alderman *et al.*, 1995). The unitary models lead to several policy failures in agricultural as because it was targeting one individual (household head) rather than targeting other household members (Haddad *et al.*, 1994; Strauss & Thomas, 1995) leading to non-adoption or poor outcomes of various agricultural policies. According to Mattila-Wiro (1999) and Alderman *et al.* (1995), the model would be appropriate in society where the household head acts as dedicator and other members remain passive. The model did not incorporate the process and basis by which resources may be distributed amongst the members of households, either by age or gender or relation with the household head. Under these circumstances, the utility of the household head or 'patriarchy' would also represent the utility of other household members. Ideally, each individual in the household has his/ her own preference and must maximize his/her own utility relatively to his/her own budget constraints (Chiappori & Donni, 2009). Thus, resources would be individually distributed. Each individual' preferences also need to be separately considered while assessing the welfare of the household (Alderman *et al*., 1995; Browning & Chiappori, 1998; Haddad *et al.,* 1994). In the context of this study where any of the spouses might be a household head, the consumption and production allocation decisions of household resources would be collectively made.

Collective Model of Household Behaviour

Alderman *et al.*(1995) argued that the life of the farm household would be better explained through the collective model. The collective model treats the farm household as a combination of distinct individuals with different preferences (Chiappori, 1997). Under collective model, it is assumed that nobody is forcing his or her preferences on other members (Chiappori, 1997; Chiappori, 1992; Chiappori & Donni, 2009). The authors showed that household individual' preferences are identified from the observable behaviour and the individual utility functions are identified depending on their own consumptions. This explains the rules of allocating individual consumption and welfare within the farm households. Furthermore, household demands are more sensitive to the intra-household distribution of resources and to environmental variables that may influence the decision

process (Browning & Chiappori, 1998). Thus, contrary to unitary model, collective model is more based on household resources distribution amongst the household members (Becker, 1993; Beninger & Laisney, 2002; Samuelson, 1956). In the context of this study, the data generated are devoted to the collective estimation of household as whole. The results of the collective estimations have been used to identify the household decision making from the spouses' behaviour on the use agricultural financing in agricultural activities.

However, focusing on individuality of the household members, the household decision making process is mostly based on two types of collective model. These are: cooperative and non-cooperative collective models. On one hand, in cooperative collective model, household member decides to invest resources in common interest shared by other household members. The cooperative collective model begins by noting the benefits accrued from the household formation, that would be shared to household individuals while pooling household resources rather than remain alone. Obviously, household is more efficient way of produce household goods and services which are later distributed by household members but not by single individuals (Alderman *et al.*, 1995). The household allocation or distribution decisions would depend only on the level of utility and the negotiating powers of the family members (Browning & Chiappori, 1998; Haddad *et al.*, 1994; Samuelson, 1956; Strauss & Thomas, 1995). However, the model does not make any assumption on how resources could be allocated or distributed. Consequently, the key issues that remain within the cooperative collective model are to know the extent to which the household resources are pooled and the rules that govern the distribution of the household members' resources.

On the other hand, household members have different preferences. Household members may decide to invest their resources irrespective of other household members. Everyone acts independently and controls his or her own income to achieve higher individual utility (Haddad *et al.*, 1994). The study considered the assumptions stating that the income is not pooled within the household, rather the share of a household expenditure resulted from particular goods is determined based on the intra-household resources distribution. Recent studies have used the cooperative collective model to analyse household behaviour on decision making in agriculture. Hoddinott and Haddadt (1995) in their study on "Does female income share influence household expenditures? Evidence from Cote d' Ivoire" have found that income is not pooled. The study also found that increasing women's share of cash income increased their budget share for food and decreased their budget share for alcohol and cigarettes. This shows how changes in household and individual income

distribution affect the household consumption patterns. Therefore, non-cooperative collective model indicates how the behaviour of household members may influence investment decision making.

2.9 Conceptual framework

This section discusses the factors that may influence the potato farmers' decision to participate to agricultural value chain finance. Four factors including socioeconomic factors, institutional factors, marketing factors and financial factors have been identified as factors that affect the famer's decision to participate on agricultural value chain financing.

Socioeconomic factors such as farmer characteristics (age, gender, level of education, marital status, size of household, farming experience, household income….), farm characteristics (land size, labour force) and farm investment cost (inputs, labour cost) determine the farmer's decision to participate or not to participate on agricultural value chain financing.

Institutional factors refer to regulations that influence the farm household's decision to access agricultural value chain finance. Farmers who use agricultural value chain finance either from formal or informal sources are empowered to access improved seeds, chemicals and farming technologies. Participation to potato farmer groups and training on agricultural practices facilitate farmers to access agricultural inputs, hence increase productivity. Obviously, a change in productivity mostly depends upon the changes in types and quantities of inputs and technology used (Olayide & Heady, 1982). Similarly, access to market information, availability of infrastructural facilities, transport and communication fees, pricing policies as well as training in market choice can determine the farm household's decision to choose source of finance and market outlets for his/her potato produce.

Furthermore, financial factors and marketing factors constituted the considerable factors for a farmer to choose the source of finance and market. Depending on the volume of potato agricultural activities, farmers considered the loan requirements, interest rate, cost of borrowing and the ability to pay back the loan before deciding on where and how much to borrow. With respect to market factors, farmer only had to reduce transaction cost by considering distance between both the farm and the potential market, quantity demanded, and quantity supplied and the selling price to decide about potential market outlets for potatoes.

In brief, the above discussed factors could jointly affect the farmer's decisions of using agricultural finance to increase potato productivity and improve access to market. Figure 5 illustrates the interactions and interrelationships of the key variables used in the study.

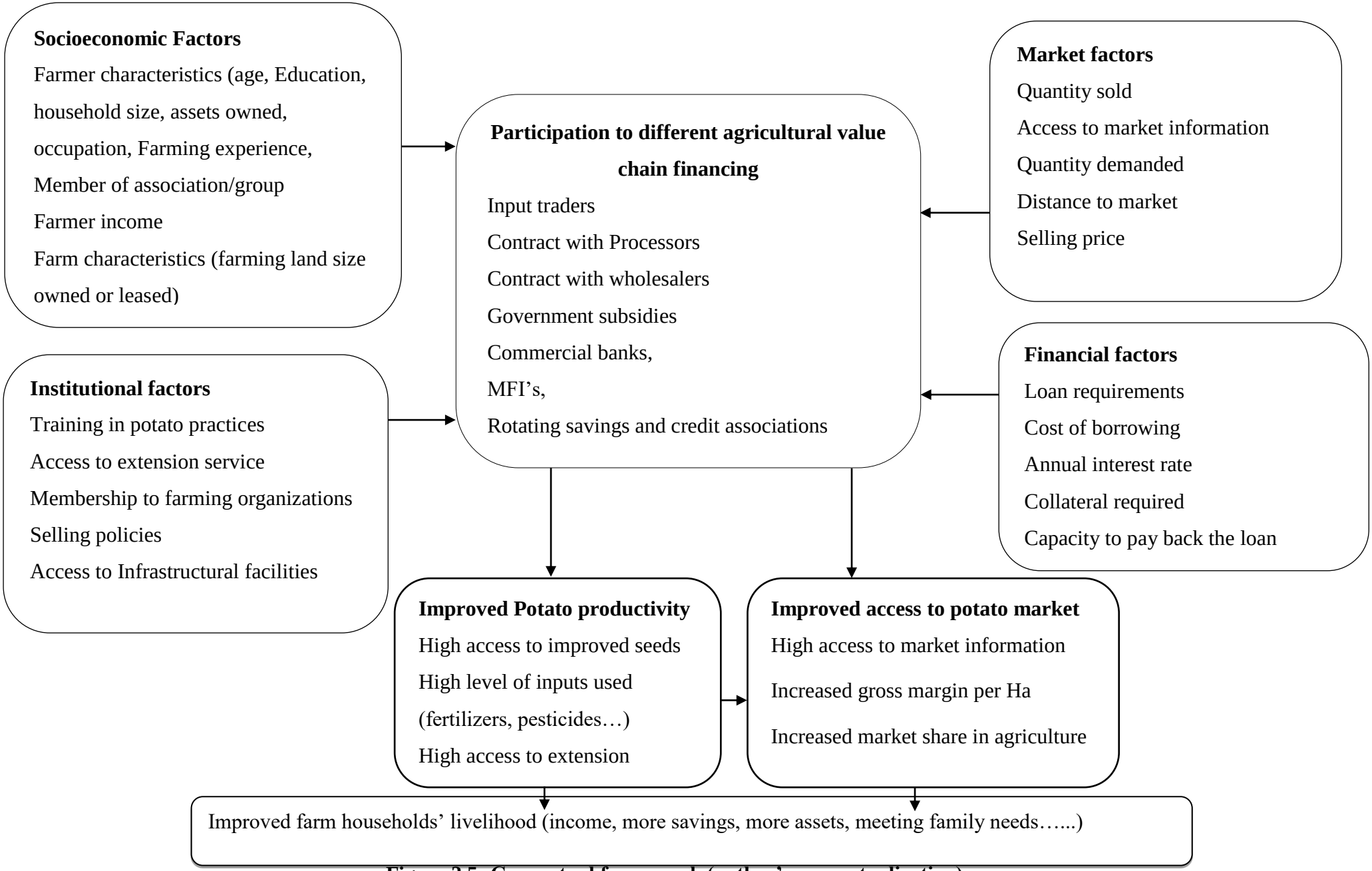

Figure 2.5: Conceptual framework (author's conceptualization)

CHAPTER THREE
METHODOLOGY

3.1 Description of the Study Area

While potato is grown throughout the country, production is particularly dominated by seven producing districts namely Burera, Gicumbi and Musanze (Northern Province), Nyabihu and Rubavu (Western Province), Nyamagabe and Nyaruguru (Southern Province) (MINAGRI, 2013). The study has been conducted in North-West volcanic zone which covers Musanze, Burera, Nyabihu and Rubavu districts. The zone is a highly agricultural potential zone, characterized by steeply sloping hills, high altitude, fertile volcanic soils and abundant rainfall favourable for potato. The four districts are the major potato growers and supply potato to the entire country and to neighbouring countries of Democratic Republic of Congo and Burundi. Furthermore, the zone is responsible for more than 60% of the total potato national production (FAO, 2016) and more than 80% of the households draw their livelihood from potato crop.

However, due the time and financial constraints, the researcher has decided to conduct his study on potato farmers from Musanze and Nyabihu Districts. The two districts are situated within the same agroecological zone of fertile volcanic soil that is favourable for potato growing. The farm households from the study area were expected to represent other farmers from the other districts in the zone. Figure 5 illustrates the localization of study area.

3.1.1 Musanze District

Musanze District is one of the five districts of Northern Province. Musanze district is divided into 15 administratively sectors: Busogo, Cyuve, Gacaca, Gashaki, Gataraga, Kimonyi, Kinigi, Muhoza, Muko, Musanze, Nkotsi, Nyange, Remera, Rwaza and Shingiro. It is the most mountainous district in the country of 530.4 km^2 with 60 km^2 of the Volcano National Park and 28 km^2 of Lake Ruhondo. The district is situated at an altitude of 1850 m with climate of $18^oC/66.2^oF$ and average rainfall of 1000-1200mm (Musanze District, 2013). According to the 4^{th} Rwanda population and housing census, the district is highly populated district with 368267 people, with an average density of 694 inhabitants per km^2 that represents 3.9 % of the total population of Rwanda (NISR-EICV3, 2012a). With its agreeable climate and soil fertility, Musanze District presents its uniqueness of being a city of investment potentials where 90 % of district's population is employed in agricultural activities. Generally cultivated 2-3 times a year, potato remains the important crop and source of income for the population of Musanze District. Nevertheless, low production and

quality seeds, inadequate extension services, poor storage facilities, low market price, and low access to credit continue to hamper the potato farmers' activities in Musanze District.

3.1.2 Nyabihu district

Nyabihu District is one of the seven districts of the Western Province. The district is divided into 12 administrative sectors that are Bigogwe, Jenda, Jomba, Kabatwa, Karago, Kintobo, Mukamira, Muringa, Rambura, Rugera, Rurembo and Shyira. Nyabihu District borders with Musanze District and Volcanoes National Park which separates it with the democratic Republic of Congo (DRC) in the North, Ngororero and Rutsiro Districts in the South, Gakenke District in the East and Rubavu District in the West. Nyabihu district is mountainous district of 537.7 km^2, its population is estimated to 294,740 inhabitants with a very high density estimated to 555 inhabitants per square km at 1% population growth (NISR-EICV3, 2012b). The district is characterised by a reliable rainfall with annual amount of 1400mm which makes it to be of the coldest places in Rwanda, maximum temperature of 15^oC and minimum temperature ranges between 10^oC to 16^oC. The agri-ecological conditions are very diverse and include fertile soils favourable for plenty of cash and food crops grown extensively. Potato crop dominates other crops (83.7 %), followed by maize (74.3 %) and beans (71.9 %) of the total farmers. According (NISR, 2018) report, Nyabihu leads other districts in producing more potato in Rwanda with 102,379MT a year .

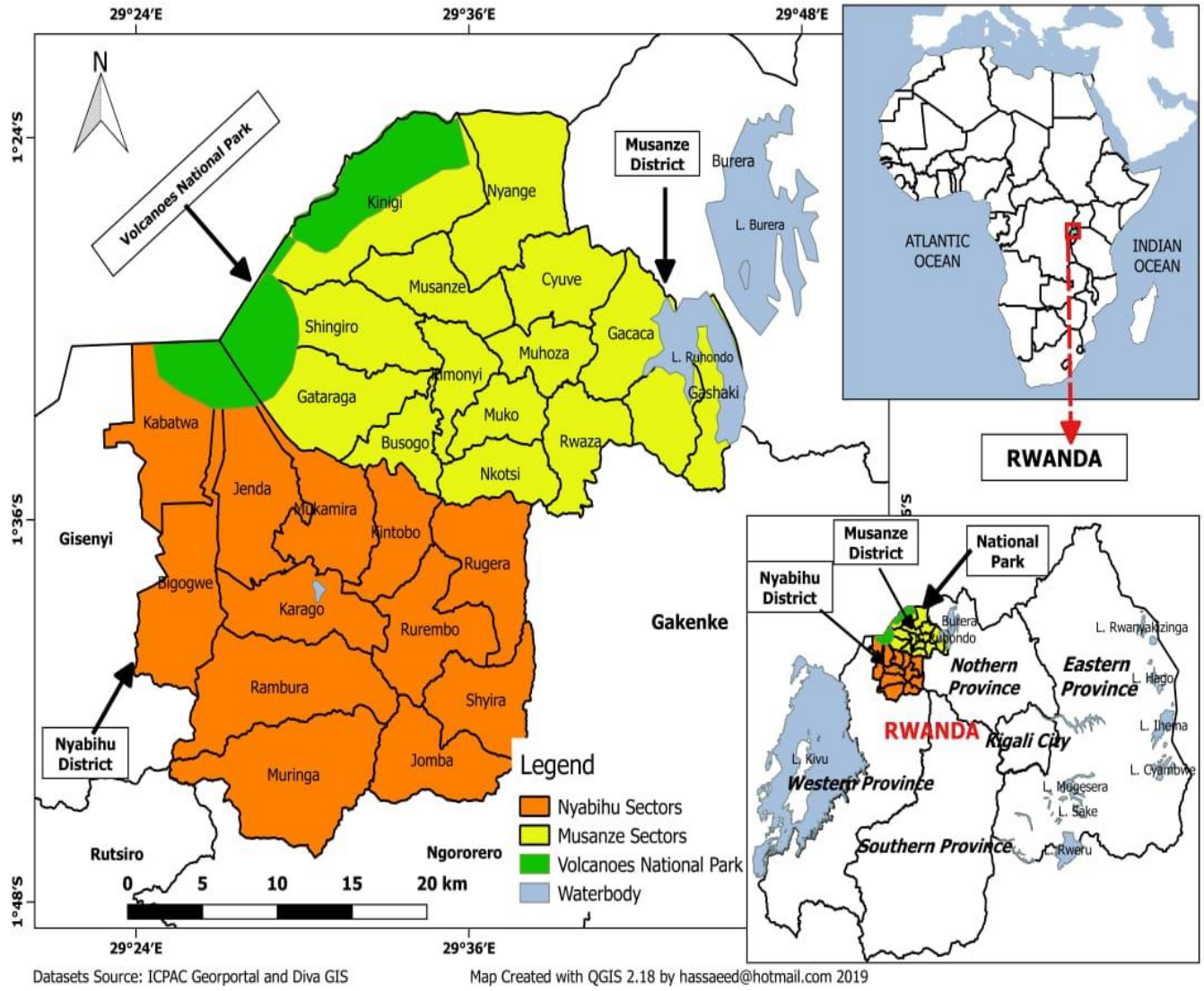

Figure 3.1: Map of Africa and Map of Rwanda showing the study area

Source: ICPAC Geoportal and Diva GIS

3.2 Research design

According to Kothari (2004), a research design is the arrangement of conditions for collecting and analysing the data in a manner that aims at combining relevance to the research purpose with economy in procedure. This study adopted a cross sectional research design that combines descriptive and analytical research design. The cross sectional design was chosen as one of the adequate data collection methods to investigate the relationship between the access to and use agricultural value chain finance and increase of potato productivity and improve of farmer's access to market. Both quantitative and qualitative data were collected and analysed using questionnaires and interviews. However, before collecting data enumerators were trained on questionnaire administration and a preliminary survey has been conducted to evaluate the completeness, precision accuracy and clarity of the survey techniques used to collect data through face-to-face interviews with farmers.

3.3 Target population and sampling

3.3.1 Target population

According to Kombo and Tromp (2006) a target population is a collection of individuals, objects or items from which the samples are taken for measurement. The target populations were all smallholder farm households growing potato in Musanze and Nyabihu Districts. The population was purposively selected to represent the major characteristics of potato producing areas in Rwanda. The unit of measurement was the farm household involved in production and sale of potato produces at any of the market outlets in Rwanda. The total number of target population is 37332 households distributed as follows: Musanze District 17879 households (Kinigi 6311, Nyange 6354 and Gataraga 5214); Nyabihu District 19453 households (Mukamira 6224, Jenda 7748 and Karago 5481). The three sectors from each district were purposively selected as the main potato producing zones in the two districts.

3.3.2 Sample size and sampling method

Considering that the exact number of potato farm households is not known, the sample size was selected from the potato smallholder farm households in Musanze and Nyabihu Districts using the formula developed by Cochran (1977). The mathematical model to calculate the sample size is as follow:

$$n_0 = \frac{z^2 pq}{e^2} \quad \text{.....(3.1)}$$

Where n_0 is the sample size of the group, z^2 is the value of a normal distribution that cuts off an area α at the tails (1 – α equals the desired confidence level set at 95 % confidence), z value is 1.96 found in statistical tables that contain the area under the normal curve. Assume p is the estimated proportion of the population potato farmer for which the variability in proportion is not known (assume maximum variability p=0.23). This proportion results in a sufficient and reliable size, particularly when the proportion of the population is not known with certainty. q is the weighted variable computed as (1-p) and e of ± 5% is the desired level of precision.

When the formula is applied, the sample size is:

$n_0 = \frac{z^2pq}{e^2}$= ((1.96)^2*0.23*(1-0.23))/ (0.05)^2=272……..…….(3.2)

However, the figure of 272 was approximated to 275. The 275 farmers were potato farmers' participants to agricultural financing. To determine the sample size from the two the study areas, the sample was proportionally distributed to the actual number of potato farmers of four sectors randomly selected from the study areas. These are Kinigi and Nyange Sectors of Musanze District, Jenda and Mukamira Sectors of Nyabihu District.

The following formula was used to distribute farmers into respective sectors:

$n_i = \text{n}\frac{N_i}{N}$…….…….…….(3.3)

Where n_i represents a total number of respondents to be sampled from each sector, N_i is total population in a selected sector and N stands for the total targeted population.

In addition, 310 farm households having similar socioeconomic characteristics as of the participants were selected from two sectors Gataraga Sector of Musanze District and Karago Sector of Nyabihu District were selected and were considered as control or untreated group. The number was obtained by arbitrary adding 35 independent households on the sample size to ease the comparison of effects of agricultural value chain financing on potato productivity and market access on farm households' livelihood. This led to a total of 585 potato farmers selected as presented in table 3.

3.3.3 Sampling procedure

A combination of probability and non-probability sampling methods was used to select the respondents. The study adopted multistage procedure to select the sample size of smallholder potato farmer households to interview. The study has used the following four stages districts, sectors, treated and control strata and farmer households. On first stage, research areas

Musanze and Nyabihu Districts were purposively selected for their agro ecological potentials including volcanic soils, high altitude, and abundant rainfall favourable to potato production. The selection of the two districts was also justified because they are the highest potato producing districts in Rwanda. In the second stage, 3 sectors from each district were selected purposively based on the production level and diversity of potato activities in the sector. In the third stage, potato farmers were stratified into two strata, potato farmer participants and non-participants to agricultural loans. Potato farmers from the two sectors were considered to be a treated group while farmers from the 3rd sector were considered to be a control group.

In Musanze District, farmers from Kinigi and Nyange Sectors were considered as treated group while farmers from Gataraga Sector were considered as control group. In Nyabihu District, farmers from Jenda and Mukamira Sectors were considered as treated group while farmers from Karago Sector were considered as control group. The study used a list of potato farm households' organizations obtained from sectors agricultural development officers. To achieve a greater representation from each sector, the distribution of sample in sectors was proportionate to the actual number of potato farmers in the sectors. In the fourth stage, to determine the famer households from the two strata (participants and non-participants), the study used systematic random sampling at interval of ten from the list of potato producers.

Table 3. 1: Sampling procedure

Stages	**Sampling units**	**Sampling techniques**	**Sample size**
One	Districts	Purposive sampling	2 (Musanze and Nyabihu)
Two	Sectors	Purposive sampling	6 (3 sectors from each district, 2 of them were treated group and another one was control group)
Three	Potato farmers	Stratified sampling	2 (Participants and non-participants to agricultural loans)
Four	Farmer households	Systematic sampling	585

Table 3. 2: Sample size distribution

District	Sector	Participants	Non-Participants	Total
	Gataraga		151	151
	Kinigi	65		65
Musanze	Nyange	66		66
	Karago		159	159
	Jenda	80		80
Nyabihu	Mukamira	64		64
Total		**275**	**310**	**585**

3.4 Data collection methods

Both primary and secondary data collection methods were used. A semi structured questionnaire with both open and closed ended questions was used to collect primary data. Data related to the potato production (plantation), harvesting, constraints on potato production, smallholder access to markets and market outlets were collected from individual farmers and farmers' organizations. Before data collection, a two-day training for 11 enumerators was organized on the ethical conduct required during the survey and type of information to collect. To test the appropriateness, the questionnaire was pretested on 20 farm households. This served to evaluate the design and relevance of questions, and estimate the time required to complete the interview. Consequently, some modifications and corrections were made on questionnaires. The data were collected during the day hours and every evening a short meeting between the researcher and enumerators was held to evaluate the progress and address emerging issues.

Apart from smallholder farm households, 2 focus groups discussions each group comprised of 8 to 10 people, and 10 key informants' interviews were conducted to enrich data related to models of financing and risks of financing the potato value chain. These included the sectors' agricultural development and extension staffs, credit officers of banks, Microfinance institutions and "umurenge" SACCO's. Secondary data related to agricultural value chain financing systems, potato production and potato marketing were gathered from journals, reports and published works available on internets.

3.5 Testing the validity and reliability of the instrument

Testing the validity and reliability of scores on the instruments lead to a meaningful interpretation of quantitative and qualitative data (Creswell, 2009). This is recommended to minimise the sampling errors and increasing the response rate. Therefore, to ensure the validity of the questionnaire, the content validity has been tested. To evaluate appropriateness design, content, clarity, and relevance of questions as well as the time required for interview. The questionnaire has been pretested on 20 farm households selected from Busogo sector located near to the training hall and was not part of the sample of the survey. Prior to the actual survey, the researcher had a consultation meeting with enumerators to test the validity of the questionnaire and appropriate modifications have been made. The information collected during the pretesting, have been used to test the reliability or the consistency (Gliem & Gliem, 2003).

3.6 Data analysis

Potato farmer households were considered as unit of analysis because the decisions to use on agricultural loans or not to use agricultural loan are taken at household level. The data was analysed using two statistical packages for social sciences STATA 16 and SPSS 16. Statistical Packages for Social Sciences (SPSS) were used to obtain the descriptive statistics of the qualitative data such as percentage, frequency, means, maximum, minimum and standard deviation. These were used to analyse socioeconomic and demographic characteristics of potato farmers' households, microfinance and financial institutions offering agricultural loans to farmers. Cross tabulations were used to examine the relationship between the variables. Statistical Data Analysis software (STATA) version 16 was used to analyse the data by applying the models proposed for achieving the specific objectives of this study.

3.7 Analytical framework

This study has relied on cross sectional data. In accordance with the research objectives, economic models were used to analyse the data.

3.7.1 Objective one:

The first objective aimed at determining the factors influencing potato farmers to participate in agricultural value chain financing in Rwanda. Probabilistic models such as logistic, linear probability model and probit models are appropriate in analysing factors

influencing smallholder potato farmers' decision to participate and use agricultural value chain financing. The variable of interest was decision of the farmer to participate and use agricultural finance. The response variable is binary in nature and therefore the three models would be appropriate. However, the linear probability model does not bound predicted probabilities between 0 and 1 and therefore not considered for this analysis (Wooldridge, 2013). Furthermore, logistic regression and probit model produce similar results but there are differences in terms on scaling because of the types of distribution they are based. Whereas logistic regression relies on logistic distribution, probit regression model assumes a normal distribution. The assumption of study was that the data were normally distributed and therefore probit model was more relevant.

Probit model was used in the study to analyse determinant factors influencing smallholder farmers participation in value chain financing in Rwanda. To meet liquidity requirements for the purchase of inputs such as seeds, fertilizers and hire cost of labour, the potato farmer can either rely on off farm income or borrow. According to Schultz (1964), farmers in traditional agriculture always act rationally within the context of available resources and technology. The demand for credit is defined as the utility that the farmer is expecting from the credit which can be expressed as:

$U= U(X_1, X_2,\ldots\ldots\ldots X_n)\ldots$ ……..…. (3.4)

Where U is the total individual utility, it is assumed to be a function of goods and services to be consumed. X_i being the individual household demand to consume or invest, $i=1,2,\ldots\ldots n.$ Knowing that nothing is offered freely, let $p_1, p_2,\ldots\ldots p_n$ represent the prices of goods and if household income is equal to its expenditures, then total income can be represented as:

$Y= p_1 X_1, p_2 X_2,\ldots\ldots p_n X_n$ .....(3.5)

However, the use of credit makes it easier for farmer household to meet the budget constraint and increase the ability to consume or invest in goods and services. Farmers have the full right to request credit from any sources. Following Petrick (2004), the maximum amount that he /she can borrow depends on the many factors including income, farm household's socioeconomic and production characteristics, the fulfilment of the credit requirements and other factors important to determine the farmer's decision to use credit services. If a farmer demands for credit and receives less than he/she has demanded, the farmer is credit constrained. If the farmer demands for credit and is able to get the desired amount, then the farmer is not credit constrained. Let F_i represent the price of credit (Interest and other charges) the $FD_i= rF_i$ represent demand for credit, subject to farmer household characteristics.

$FD_i=f(Y, H, V…Z)$……...…(3.6)

However, according to the literature, to participate and use of agricultural loan depends not only on the farmer's observable characteristics. It is also a function of some unobservable characteristics which if not controlled for can overestimate, underestimate or report impact where none exists at all. Therefore, the variables that may constrain farmer households' decision to use or not use agricultural loans include socioeconomic, demographic, institutional, and financial and market factors (Baltenweck *et al.*, 2006, Shili & Umali, 2007, Sirak & Bahta, 2007).

Therefore, farmers are portioned into two categories: farmers who participated and used agricultural loans and farmers who did not. Then, P_{it} can be expressed as follows:

$P_{it=} f(X_1, X_2,…….X_n)$……...…… ……...…….(3.7)

Where P_{it} takes the value 1 if farmer's marginal utility of using agricultural loan is greater than 0, P_{it} takes the value 0, if otherwise. X_1, X_2,….X_n being the farmer household characteristics and other factors important to determine the farmer's decision to use the loan. While we observe the values 0 and 1 of variable P_{it}, there is a latent unobservable continuous variable P^*_{it} that determines the binary censoring, expressing the utility the smallholder farmer get from participating in agricultural loan.

Assume P^*_{it} represent the critical decision point for a farmer to use agricultural loan or not. P^*_{it} can be specified as follows:

$P^*_{it}= \beta_o+ \beta_1X_1+ \beta_2X_2+…. + \beta_nX_n+ \mathcal{E}_{it}$……..(3.8)

and that P_{it} =1 if P_{it} *>0, (if farmer participated)

P_{it} =0 if P_{it} * ≤ 0 (otherwise)

From (3.8) $Pr(P=1)= Pr (\beta_o+ \beta_1X_1+ \beta_2X_2+…. + \beta_nX_n+ \mathcal{E}_{it)} >0)$…….. (3.9)

Farmer *i* uses loan if $P_{it}>P^*_{it}$, $P^*_{it}>0$; farmer *i* do not use the loan if $P_{it}<P^*_{it}$, $P^*_{it}\leq 0$

The error term is assumed to be normally distributed so that probability that $P_{it} \leq P^*_{it}$ can be computed from the cumulative normal probability function. Thus, the empirical model to be used for probit model becomes:

$P^*_{it}= \beta_o+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5+ \beta_6X_6+……. + \beta_nX_n+ \mathcal{E}_{it}$ ..... (3.10)

P^*_{it} reveals the willingness of farmer to use agricultural loan, X1, X2,…., X_n explanatory variables are factors influencing to take decision to participate and use agricultural loan, coefficients β_1, β_2 … β_n provide consistent estimates of the explanatory variables and ε_{it} the error term normally distributed with constant variance.

Based on the conceptual framework, the empirical model was estimated using farmer's characteristics assumed to influence their agricultural loan decisions. These include farm and farmer's characteristics such as age, sex, marital status, household size, education level, Log household income, household assets, total land size, membership to farming organizations, training in potato practices, farming experience and distance to markets. The empirical model used to determine the factors influencing farmer's decision to participate and use agricultural value chain financing was as follows:

Pit =βo+ β1 age+ β2 Sex+ β3 marital status+ β4 Household size+β5 Education+ β6 Household income+ β7 asset household (Land) + β8 asset household (house) + β9 asset household (livestock) + β10 asset household (transport equipment) + β11 Total land size+ β12 Membership to farming organizations + β13 training in potato practices + β14 Farming experience of household head in potato practices+ β15 distance to markets +Ɛit.....(3.11)

Table 3. 3: Description and measurement of dependent and independent variables used in probit model

Variables	Variable description	Measurement	Expected sign
Dependent variable			
Acc-Us_Agr_Crd	Decision for Access and Use of agricultural credit	Dummy 1=Yes, 0=No	N/A
Independent variables			
Sex_HH	Gender of household head	Dummy 1=male, 0=female	+/-
Age_HH	Age of household head	Years	+
Educ_HH	Level of Education of household head	Categorical 0=no formal education 1=Primary education 2=Secondary education	+
Mar_HH	Marital status of household head	Dummy	+

		1=Married, 0= otherwise	
Farm_exp	Farmer 's experience in farming	Years	+
Size_ H	Size of Farmer's household	Ha	+
Log_Inc_H	Log Farm household income	Continuous	+
Farm_Size_HH	Total farm/land size owned by household head	Continuous (Ha)	+
House_asset_H	House assets owned household head	Dummy 1=yes, 0=no	+
Livestock_asset_H	Livestock assets owned household head	Dummy 1=yes, 0=no	+
Trans_Asset_H	Transport assets owned household head (facilities equipment)	Dummy 1=yes, 0=no	+
Mbr_farm_org	Member of farming organization	Dummy 1=yes, 0=no	+/-
Train_Ptt_HH	Household head received training in potato production practices	Dummy 1=yes, 0=no	+/-
Distan_Mkt	Distance between household farm gate to nearest potato market (Km)	Continuous (Km)	-

3.7.2 Objective two:

The second objective was to evaluate the effects of agricultural value chain financing on potato productivity in Rwanda. The researcher was interested to evaluate the impact of agricultural value chain finance on potato productivity. To tackle this objective, propensity score matching model (PSM) and Endogenous switching regression (ESR) were used. The outcome variables were potato productivity which was measured as quantity harvested by acre of land planted (kg/ha). The response variable is a continuous and multiple linear regression estimated by ordinary least squares would be relevant. Ideally, OLS regression would consider participation in potato financing as one of the predictors of productivity.

However, multiple linear regressions do not account for self-selection bias that arises from non-random nature of participation in agri-financing. Alternative models include instrumental variable, PSM, and ESR. Instrumental variable regression was not used because it does not allow calculation of treatment effects of the untreated group.

Propensity Score Matching (PSM)

PSM is an alternative method to evaluate the average effect of a programme on participants' outcomes and conditions of participation. Matching involves pairing treatment and control units with similar values in terms of their observable characteristics, and possibly other contextual factors, as well as discarding full unmatched units (Dehejia & Wahba, 2002; Rubin, 2001). According to Baker (2000), the PSM addresses the problem of self-selection bias which results from the non-participation of the program. It is used to compare two groups of subjects but can be applied to analyse more than two groups. In order to assess the impact of the treatment effectively, there is a need to establish the counterfactual, to express what would have happened to the productivity (Kg/Ha) if potato farmers had no access to agricultural loan. Under such conditions, a comparison between similar observable characteristics is used in order to estimate the appropriate counterfactual (Friedlander & Robins, 1995).

The challenges arise because the aim of PSM is to clearly distinguish between participants and non-participants to the programme. Under cross-sectional data, it is not possible to observe both outcomes for a given household simultaneously and taking the mean outcome of the non-participants as an approximation in working difference is not advisable, because the participants and non-participants differ even in absence of the program. An effective way to address such problem is to resort to an investigation of the direct effect of agricultural loan by analysing the differences in outcomes among farm households (Dehejia & Wahba, 2002). The basic purpose of PSM model is to match the observations of non-participants who are similar to participants in all relevant pre-participation characteristics according to the predicted propensity of participating on agricultural loan (Smith *et al.*, 2005;Wooldridge, 2005) . The group of individuals identified serves as a control group in evaluating the effects of the programme. Observed difference between the control group and treatment group (participants) can hence be attributed to the programme.

The PSM was chosen because of its appropriateness in the estimation of causal effects in non-experimental setups. This model is also proposed as a way of correcting the estimation of effects of the programme controlling for the existence of the confounding factors based on

the idea that bias is reduced when the comparison is performed using participants and control subjects who are as similar as possible (Owuor, 2009). Individuals, treatment and potential outcomes were the model's main pillar.

To develop the PSM, let "i", denotes individual farmer, where i=1, 2…. n total farmers, D_i denotes a dummy variable such that D_i=1 indicates agricultural loan participants and D_i=0 for non-participants. The potential outcomes for potato farmers are then defined as (D_i=1) is Y_i (1) for participants and (D_i=0) is Y_i (0) for non-participants. The treatment effect can be written as T_i= Y_i (1)-Y_i (0) ……...(3.12).

The treatment evaluation problem occurs since the possible outcome Y_i (1) = Y_i is observed, and Y_i (0) is unobserved for each individual "i". The unobserved outcome is called counterfactual outcome. Hence, estimating the individual treatment effect T_i is not possible for every farmer and one has to concentrate on the average treatment effect. The most focused parameter is the average treatment effect of the treated individuals (ATT) which is defined as: T_{ATT}= E (Y_i (1)-Y_i (0) / D_i =1) = E (Y_i (1)/ D_i =1)-E (Y_i (0)/ D_i =1) ……(3.13**).**

As the counterfactual mean for those being treated E (Y_i (0)/D_i=1) is not observed, one has to choose a proper substitute for it in order to estimate ATT. Using the mean outcome of the untreated individuals. E (Y_i (0)/D_i=0) is in non-experimental studies not recommended, because it is most likely that components which determine the treatment decision also determine the outcome variables of interest. Thus, the outcome of individuals from treatment and comparison would differ even in the absence of treatment leading to self-selection bias. For ATT, it can be noted as:

E [Y_i (1)/D=1]-E [Y_i (0)/D=0] = ATE+E [Y_i (0)/D_i =1]-E [Y_i (0)/D_i=0] ...…….(3.14).

No experimental studies assignment to treatment is non-random. Average Treatment effect (ATE) =E [Y_i (1)**]** -E [Y_i (0)]. To estimate this, both counterfactual outcomes have to be constructed these being E [Y_i (1)/D_i=1] and E [Y_i (0)/D_i=0]. According to Rosenbaum & Rubin (1983), the propensity score can be evaluated as P(X)=P(Di=1/X). One strategy of identification of counterfactuals is to presume that a set of specific observable covariance X which are not affected by treatment makes a potential outcome independent of treatment assignment, that is conditional independence assumption. Un-confoundedness, which is Y_i (0), Y_i (1) ⊥D/X, ∀ X, and ⊥ denotes a statistical independence. This implies that selection is solely on observable characteristics and that all variables that influence treatment assignment and potential outcomes simultaneously are observed.

As results, if p(X) is the propensity score then D_i⊥ X P (X) ……..... (3.15). Thus, the propensity score P(D_i=1/X) =P(X)…… ……

(3.16); is the probability of an individual to participate in a treatment given observable covariates, is a possible balancing score. The conditional independence assumption based on the propensity score can be written as: Y_i (0), Y_i (1) $\perp D_i/P(X)$, $\forall$ X… ……..…(3.17).

Based on the above assumptions, potential outcomes of the comparison group are independent of participation. Therefore, after adjustment of the observable differences, the mean of the potential outcomes for $D_i=1$ and $D_i=0$ is the same, this shows that: E [(Y_i (0)/D_i =1), P(X)] = [(Y_i (0)/D_i=0), P(X)] ……(3.18).

A further requirement besides independence is the common support or overlap condition $0<P (D_i=1/X) < 1$. It assumes that for the farmers with the same X values have positive probability of being both participants ($D_i=1$) and non-participants ($D_i=0$). Given conditional independence assumption holds and overlap (strong ignobility) between both groups, each participant has a count part in the comparison group (Friedlander & Robins, 1995). The ATT can be written as the mean difference in outcomes over common support, appropriately weighted by the propensity score distribution of participants. ATT can now be estimated as: = E [Y_i (1)- Y_i (0)/D_i=1] = E [E (Y_i (1)- Y_i (0)/D_i=1, P(X))]=E [E (Y_i (1)/D_i=1, P(X))- E (Y_i (0)/D_i=0, P(X))] ……..……...(3.19).

This approach might yield to biased estimates because it assumes that access to agricultural loan is exogenously determined while it is potentially endogenous. Therefore, examining the effects may be difficult if the distinctions in productivity among participants and non-participants are simply attributed.

Endogenous Switching Regression (ESR)

Though PSM models are more popular methods of pre-processing data for causal inference of observational data, they often increase imbalances, inefficiency, model dependence, and then do not produce consistent estimators in the presence of hidden bias (King & Nielsen, 2016). Access to agricultural finance is an indirect input into production process used to purchase other factors like fertilizers and hired labour. Therefore, it is an exogenous variable in the same production function to influence productivity. The propensity score is a continuous variable and there is no way of getting productivity with the same score as its counterfactuals. The decision to participate or not to participate is voluntary and may be based on individual self-selection. Farmers that participate have systematically different characteristics from the farmers that do not participate, and they may decide to participate based on expected benefits. It is necessary to search for the methods that can provide reliable

estimators of causal effect even when different assumptions are used. Consequently, to resolve this problem and to complete PSM, endogenous switching regression models (ESR) was applied (Asfaw & Shiferaw, 2010; Owuor, 2009). The ESM model was used to analyse the endogeneity of participation decisions (heterogeneity in the decision of selecting to participate or not in agricultural finance and unobservable characteristics of farmers) through an estimation of a simultaneous equations model with endogenous switching using full maximum likelihood estimation, whereas the PSM model was used to resolve the econometric problems and assess the robustness of the results (Asfaw, 2010). Let's specify the equation of farmer's decision to participate to agricultural loan be as follows:

$I_i^* = \beta X_i + \mu_i$ with $I_i = 1$ if I_i^* is >0; $I_i = 0$ if otherwise……..….(3.20)

Where I_i^* is the unobservable or latent variable for the credit participation, I_i is its observable counterpart if farmer borrowed to increase productivity, β is the parameter to be estimated, X_i are non-stochastic vectors of observed farmer characteristics determining the use of loan and μ_i is random disturbances attributed to the use of loan.

The binary response is also defined as:

$Y_i^* = \alpha J_i + \beta I_i + \mu_i$ with $Y_i = 1$ if Y_i^* is >0; $Y_i = 0$ otherwise…….…..... (3.21)

where Y_i is the main outcome variable and Y_i^* is the latent variable, α represents a vector of parameters to be estimated, $J_i$is a vector of explanatory variables, I_i is endogenous dummy to Y_i, β is the coefficient of endogenous treatment dummy and μ_i is an error/residual term.

The equation (3.21) is considered as an endogenous switching regression model with two separate equations of agricultural loan participants and non-participants subgroups. Therefore, to count for the selection bias problem, the equation for estimating productivity outcomes needs to proceed in the first stage to correct the selection bias where farmers face two regimes of participants either to use loan (1) or not to use loan (2) expressed as follows:

Regime (1): $Y_{1i} = \alpha_{1i} J_{1i} + \varepsilon_{1i}$ $I_i = 1$ if $I_{1i} > 0$ for loan users sub-group…… (3.22)

Regime (2): $Y_{2i} = \alpha_{2i} J_{2i} + \varepsilon_{2i}$ $I_i = 0$ if $I_{2i} \leq 0$ for non-loan users sub-group……(3.23)

Where, Y_{1i} and Y_{2i} are the outcomes for loan participants and non-loan participants' sub-groups respectively. J_{1i} and J_{2i} are the conventional factors that influence outcome functions for loan participants and non- loan participants respectively. I_{1i} and I_{2i} are dummies ($I_i = 1$ for participants and $I_i = 0$ for non-participants), α_{1i} andα_{2i} are the estimated vectors, ε_{1i} and ε_{2i} are random disturbances. These error terms create a trivariate normal distribution, with mean vector zero and covariance matrix expressed as follows:

$$Cov(\varepsilon_{1i}, \varepsilon_{2i}, u_i) = \begin{vmatrix} \sigma^2{}_{\varepsilon_1} & \sigma_{\varepsilon_{12}} & \sigma_{\varepsilon_{1u}} \\ \sigma_{\varepsilon_{21}} & \sigma^2{}_{\varepsilon_2} & \sigma_{\varepsilon_{2u}} \\ \sigma_{\varepsilon_{1u}} & \sigma_{\varepsilon_{2u}} & \sigma^2{}_u \end{vmatrix} \quad \text{.....} \quad (3.24)$$

Where, $\sigma^2{}_{\mu_1}$ is the variance of the error term in the equation (34), $\sigma^2{}_{\varepsilon_1}$ and $\sigma^2{}_{\varepsilon_2}$ are variances of the error terms in equations (36a) and (36b) respectively, $\alpha^2{}_{\varepsilon_{1u}}$ and $\alpha^2{}_{\varepsilon_{2u}}$ represent covariance ε_{1i}, ε_{2i}, u_i. As Y_{1i} and Y_{2i} are never observed simultaneously, the covariance between ε_{1i} and ε_{2i} cannot be defined.

To evaluate the total outcomes of agricultural value chain financing, total productivity outcomes for all farmer households' participants must be considered. That is to compare expected productivity outcomes of loan participants (Y_{1i}) and expected productivity outcomes of non-loan participants (Y_{2i}). The important application of the error structure is because error term u_i is correlated to ε_{1i} and ε_{2i} and the expected values of ε_{1i}, ε_{2i} conditional on the sample selection are nonzero:

$$E[\varepsilon_{1i}/I_i = 1] = \sigma_{\varepsilon_{1u}} \frac{\emptyset(\beta x_i)}{\theta(\beta x_i)} = \sigma_{\varepsilon_{1u}} \lambda_{1i} \;;\; E[\varepsilon_{2i}/I_i = 0] = -\sigma_{\varepsilon_{2u}} \frac{\emptyset(\beta x_i)}{1-\theta(\beta x_i)} = \sigma_{\varepsilon_{2u}} \lambda_{2i} \quad (3.25)$$

Where, $\emptyset(.)$ is the standard normal probability density function, $\theta(.)$ is the standards normal cumulative density function and $\lambda_{1i} = \frac{\emptyset(\beta x_i)}{\theta(\beta x_i)}$ and $\lambda_{2i} = -\frac{\emptyset(\beta x_i)}{\theta(\beta x_i)}$. The ration λ_{1i} and λ_{2i} is referred to the Inverse Mills Ratio (IMR) which denotes selection bias terms. If the estimate covariance $\sigma_{\varepsilon_{1\mu}}$ and $\sigma_{\varepsilon_{2\mu}}$ are statistically significant, the IMR provide the correlation between use of agricultural loan and productivity. Thus, the decision of potato farmer to access agricultural loan and potato productivity outcomes variables are correlated. This constitutes the evidence for the utilization of the endogenous switching regression model (Asfaw & Shiferaw, 2010; Maddala, 1983).

Models with endogenous switching can be fitted one equation at a time by either two steps least squares (LOS) or maximum likelihood estimation (FIML). Though both methods are inefficient and require potential cumbersome adjustments to derive consistent standard errors, FIML would be more efficient to estimate endogenous switching regression model. In order to produce consistent standard errors, the FIML method simultaneously fits binary and continuous parts of the model (Lokshin & Sajaia, 2004). Given the assumption that the error terms have a trivariate normal distribution, the logarithmic likelihood function for the system equations (34) and (35) would be as follows:

$lnK_i = \sum_{i=1}^{N}\{I_i[ln\emptyset\langle\varepsilon_{1i}|\sigma_{\varepsilon1}\rangle - ln\sigma_{\varepsilon1} + ln\theta(\varphi_{\varepsilon1})] + (1 - I_i)[\ln(\emptyset\langle\varepsilon_{2i}|\sigma_{\varepsilon2}\rangle - ln\sigma_{\varepsilon2} + \ln(1 - \theta(\varphi_{\varepsilon2}))]\}$ ……………………………………………………………………. ……… (3.26)

Where $\varphi_{ji}=\frac{\beta X_i+\gamma_j\varepsilon_i/\sigma_j}{\sqrt{1-\gamma_j^2}}, j = 1,2$ with σ_j denoting the correlation coefficient between the error term μ_i of the selection equation (3.16) and the error terms $\varepsilon_{ij}$of the equations (3.17) and (3.18). The *movestay* command in STATA can be used to estimate The FIML estimates of the parameters of the endogenous switching regression model (Lokshin & Sajaia, 2004). Prediction of the coefficients for both participation and output equation restriction was applied on the equations for predicting outcomes. Restrictions were achieved by including two independent variables as instrument in the selection equation but are not correlated with the outcome. Distance to the market and access to training on potato production practices were selected as instruments. Falsification test was conducted and the two instruments were found to be valid (Lokshin & Sajaia, 2004). The FIML has been adopted by Asfaw and Shiferaw (2010), Awotide *et al.* (2015) and others. The endogenous switching regression model can be used to compare the productivity of the farmer households that used loan (a) with the respect to farmer households that did not use loan (b).

$E (Y_{1i}/I_i=1) = \alpha_{1i}J_{1i}+\varepsilon_{1i}\lambda_{1i}$

$E (Y_{2i}/I_i=0) = \alpha_{2i}J_{2i}+\varepsilon_{2i}\lambda_{2i}$

The effect of use of agricultural loan was estimated by:

$E (Y_{1i}/I_i=1) - E (Y_{1i}/I_i=0) = (\alpha_{1i}J_{1i}+\varepsilon_{1i}\lambda_{1i}) – (\alpha_{2i}J_{2i}+\varepsilon_{2i}\lambda_{2i})$………………………….. (3.27)

Table 3. 4: Description and measurement of dependent and independent variables used in PSM and ESR

Variables	Variable description	Measurement	Expected sign
Farm _ Size _land _hh	Total size of farm/land owned by household head (size in hectare)	Ha	+
Farm _ Size _land__ ppt	Farm/ land size of to grow potato (size in hectares)	Ha	+
Lab-used	Labour used to grow potato (family and hired labour)	man-day	+
Seed_qty	Quantity of seeds used (kilograms)	Kg	+

Org_fert_qty	Quantity of organic fertilizer used (kilograms)	Kg	+
Inorg_fert_qty	Quantity of inorganic fertilizer used (Kilograms)	Kg	+
Pest&Fong_qty	Quantity of pesticides and fungicides used (kilograms)	Kg	+
Acc_extens_serv	Number of extension services received	Continuous	+
Vol_pto_hvst	**Volume of potato harvested (kgs)**	**Kg**	**Dependent**

3.7.3 Objective Three:

The third objective aimed at determining the factors influencing potato farmers' access to potato market in Rwanda. In this study, the issue of market access was centred to allowing farmers' market participation and the extent to which farmers were enabled to sell their produce to prospective buyers. To analyse the factors that influence smallholder farmers' access to market, the study addressed the possibility of selection bias to estimate the farmers' choice on whether or not to participate in the potato markets. To account for potential selection bias, the statistical selection models Hackman's two steps model, Tobit model and Double Hurdle model (DHM) would be used to analyse the two decisions that the farm household might make as regarding to participation to market and the extent of that participation. However, the application of one of each econometric model depends on the objective of the research and the type of data collected.

Heckman's model

Adeoti *et al.* (2014) have used the Heckman model to assess the determinants of market participation among Maize producers in Oyo State, Nigeria. The model as it evolved step by step Heckman's model uses a probit equation to estimate the likelihood of the farmers' decision to participate in the market. However, the inverse Mills ratio calculated from the probit regression is used in conjunction with other independent variables to explain the variance in the continuous, non-zero outcome measure (for example sales volumes). Heckman model takes into considerations the fact that the non-selling group is not a representative subsample of the population. The basic assumption of Heckman model is that a certain value of the dependent variable is observed if it is greater than a specific threshold.

Variables that influence quantity selection decision may actually affect the discrete participation decision, whereas some factors that may influence discrete participation (such as transportation costs) have no consistent effect on the outcome variables. the Heckman model uses the following linear equation for the quantity sold as follows:

$Y_i * = \beta_0 + X_{1i} \beta_1 + \varepsilon_{1i}$ ……(3.28)

The first step of the model is standard probit model which describes the likelihood of smallholder farm household's participation in the produce market h_i ;

$h_i * = X_{2i}\beta_2 + \varepsilon_{2i}$ ……..…….(3.29)

$h_i * = 1$ if $h_i * > 0$ or 0 if $h_i * \leq 0$……..…...(3.30)

Whereby h_i is the farm household's participation in the potato market. The variable h_i takes the value of 1 if the marginal utility the household I get from participating in the potato market is greater than zero, and zero otherwise. The sign and the size of the correlation coefficients for the same parameters may differ significantly between the two scenarios as illustrated in (3.25) and (3.26). And where h_i * is the latent level of utility the smallholder farmers get from participating in the market and with μ˜N (0.1), hi*= Xi βi+ μ_{1i}

The conditional expected quantity sold given that the household is participating in the potato market is:

$$E[Y_{1i}/h_i = 1] = x_{1i}\beta_1 + \sigma_{12}\frac{\emptyset(x_{2i}\beta_2)}{\theta(x_{2i}\beta_2)} \text{……(3.31)}$$

Where, σ_{12} is the covariance between the two error terms, $\emptyset$ and θ represent the standard normal cumulative distribution function and standard normal distribution respectively, the term $\lambda = \frac{\emptyset(x_{2i}\beta_2)}{\theta(x_{2i}\beta_2)}$ is the inverse Mills' ratio called the Heckman's lambda.

The ordinary least square model (OLS) is used in the second step to estimate the extent for market participation. The model uses the OLS estimation through the inclusion of Heckman's lambda among the regressors and is indicated as follows:

$$Y_i = X_{1i}\beta_1 + \sigma_{12}\frac{\emptyset(x_{2i}\beta_2)}{\theta(x_{2i}\beta_2)} + \eta_i \text{……(3.32)}$$

Tobit model

The estimation issue of participation or not deals with the censored dependent variables. According to the literature, to expand the probit model, in 1958 Tobit developed Tobit model, (Gujarati, 2004). The model is employed when the dependents variables are exceeding or low to the threshold. This should be any number and should fit the model as well particularly when the outcome value is censored between 0 and 1. The standard Tobit model is defined as Y_i*= β0+xiβ+μi……...(3.33)

Where μi ˜N(0, $\sigma 2$), where xi is a k-vector of exogenous explanatory variables and β is the parameter vector, Y_i*=is the latent variable that is observed for the values greater than 0 and censored otherwise. This is for instance if research looks for identifying the factors of farmers' expenditures on transport expenses. The individual farmers who sell nothing in the market have no data in transport expenses' variable whereas those who paid transport costs do have data. The observed can be defined by the measurement equation as below:

Y_i=0 if Y_i*= $\beta 0+x_i\beta+\mu_i \leq 0$……………………………………………………........(3.34)

Y_i= $x_i\beta+\mu_i$ if Y_i*= $\beta 0+x_i\beta+\mu_i >0$………………………………………………… (3.35)

If the data is censored at zero, the different types of censoring models can be distinguished by the observability rule on Y_i* as follows:

$$Y_i= \begin{cases} Y_i^* \ if \ \ Y_i^* > 0 \\ 0 \ if \ \ Y_i^* \leq 0 \end{cases} \quad \text{…………………………………………………………… (3.36)}$$

The extent of participation is indicated by

Y_i* = $\beta 0+ x_i\beta+\varepsilon_i$ ……………………………………………………………... (3.37)

Where Y_i* is the amount marketed, x_i is the vector of covariates that explain this amount and β is a vector of unobserved parameters to be estimated and ε_i is a random variable indicating all other factors apart from x_i.

Tobit model uses marginal effect and Maximum Likelihood regression estimation to solve problems related to factors that might affect the farmers' willingness to sell the product in market at certain levels or magnitude of sales.

$$\frac{\partial E(y)}{\partial x_i} = \emptyset(\frac{x_i\beta_i}{\sigma})\beta_i \text{……………………………………………………………… (3.38)}$$

This model contrasts with the Heckman model as single estimation in determining the choice between positive and zero sales, and quantity of produce to sell of sales given the market participation. It imposes the restriction that the same factors have the same effects upon the decisions to sell and the decision on the quantity to be sold. The Tobit model assumes that the decision for participation and intensity of participation are made simultaneously and hence using the same parameters to decide on participation in the market and sales (Burke, 2009; Reyes *et al.*, 2012). The Tobit model gives room for possible differences between factors that affect participation (μ_i , $x_{i,}$ β,) and factors that affect extent of participation (ε_i , $x_{i,}$ β) (Mujawamariya & Achandi, 2016). According to Fernando (2011) the Tobit model is observed when the dependent variable is above (right censored) or below (left censored) some cut off levels, which may lead to underestimation or overestimation of the intercepts and/or the slopes.

Double Hurdle model (DHM)

Apart from Heckman and Tobit models, the double hurdle model may be used for determining the factors influencing potato farmers 'market access. According to Gujarati (2004), Heckman two stage models is the alternative to Tobit model but the estimates from Heckman model are consistent but not sufficient as the estimates from the maximum likelihood of Tobit model. The use of double hurdle originally formulated by Cragg (1971) assumes that two separate hurdles must be passed before the level of participation to potato markets can be observed. The model involves farmers' decision to participate and extent of participate to that market. This model assumes that farmers make sequential decisions: first decide whether to participate to market, then the conditional on participation, they decide how much to sell to that market.

Both the DHM and the Heckman models are two stage econometric regression models. Heckman uses the probit in the stage one and the OLS model in the second stage whereas the DHM uses the Probit in the first stage and the Tobit model in the stage two. However, the Probit model used for the two models is not different from one or another. The two models assume similar sets of variables affecting the two decisions differently. However, using Heckman model is more appropriate for controlling selection bias through use of the inverse Mills' ration (IMR) but is opposed to the Double Hurdle because of zeros in Heckman reflect missing responses while the zeros in DHM results in non-participants. In DHM, the dependent variables are dummy variables/ binary (1= participating, 0= not participating) used to estimate the maximum likelihood estimator (MLE) of the first hurdle, which is assumed to be a probit mode. In the second hurdle, the dependent variables are continuous variables of quantity of potato sold assumed to follow a truncated normal distribution. The MLE is obtained by fitting a truncated normal regression model (Burke, 2009; Cragg, 1971) to the quantity of potato sold.

First stage: Farmer's decision to participate to potato market is represented by a latent variable estimated using with probit model indicated by:

$$P_i^* = X_i'\alpha + \mu_i \quad \text{.....(3.39)}$$

Whereby P_i^* is a latent variable indicating farmer's decision to participate to market, α is a vector of unobserved parameters to be estimated, X_i' is a vector of observed independent covariates that explain the farmer's decision, μ_i is unobserved error term capturing all factors affecting p_i apart from X_i'.

Second stage: Extent of farmer's decision to participate (quantity sold to market) is estimated using truncated normal regression (Tobit model) indicated by:

$Q_i^* = Z_i'\beta + v_i$ ……(3.40)

whereby Q_i^* is the quantity of potato sold to market, β is a vector of unobserved parameters to be estimated, Z_i' is a vector of observed independent covariates that explain the farmer's decision, and v_i is an unobserved error term that captures the factors affecting q_i apart from Z_i'. a potato farmer participate if $\mu_i > -(X_i'\alpha)$ with the probability of observing the farmer's participation given as : $Pr(\mu_i > -(X_i'\alpha))$.this model gives a room from the differences between factors that affect participation to market and (μ_i , $X_i'\alpha$)and factors that affect the extent of participation (quantity of potato to be sold) (v_i , $Z_i'\beta$). The error terms μ_i and v_i are assumed to be independent and normally distributed as $\mu_i \sim N(0, 1)$, and $v_i \sim N(0, \sigma^2)$.

The interaction between the two decisions leads to the following estimation for the model:

$P_i = X_i'\alpha + \mu_i$ if $p_i^* > 0$, and 0 if otherwise …… (3.41)

$Q_i = Z_i'\beta + v_i$ if $q_i^* => 0$, and 0 if otherwise ……..... (3.41)

The empirical model for the farmers' participation to potato market estimated by the probit model is:

$$P = \alpha_0 + \alpha_1\, age\_HH + \alpha_2\, Sex\_HH + \alpha_3\, Mar\_HH + \alpha_4 Educ\_HH + \alpha_5\, Size\_H + \alpha_6 Farm\_Size\_H + \alpha_7 Farm\_exp + \alpha_8 Incom\_H + \alpha_9 Trans\_Asset\_H + \alpha_{10}\, Memb\_Farm\text{-}Org + \alpha_{11} Distan\_Mkt + \alpha_{12} Time\_market + \alpha_{13}\, Mkt\_Price + \alpha_{14}\, Acc\text{-}Us\_Agr\_Crd + \mu_i \ldots\ldots\ldots (3.42)$$

Table 3. 5: Description and measurement of dependent and independent variables used in first stage of DHM (Farm household's market participation)

Variables	Variable description	Measurement	Expected sign
Dependent variables			
Mkt_Access_partic	Market participation	Dummy 1=Yes 0=No	**N/A**
Independent variables			
Age_HH	Age of household head	Years	+
Sex_hh	Gender of household head	Dummy 1=Male, =Female	+/-
Mar_HH	Marital status of household head	Dummy 1=Married, 0= otherwise	+
Educ_hh	Level of education of household	Categorical	+

	head	0= no formal education 1=Primary education 2=Secondary education	
Size_H	Household size	Number of people in household	+
Farm_Size_ H	Total farm/land size owned by household head	Ha	+
Farm_exp	Farm household's experience in farming	Years	+
Farm_Income_H	Farm Household income	Continuous	+
Trans_Asset_H	Transport assets owned by the household	Continuous	+
Memb_Farm-Org	Whether farm household head is member of farming organization	Dummy 1=yes, 0=no	+
Distan_Mkt	Distance between household farm gate to nearest potato market (Km)	Continuous (Km)	-
Time_market	Time required between the farmer's production and the market	Hrs	-
Mkt_Price	Market price	Frw	+
Acc-Us_Agr_Crd	Access and Use of agricultural credit	Dummy 1=Yes, 0=No	+/-

In the second stage, the DHM uses the Tobit model to estimate the extent of participation

$$Q = \beta_0 + \beta_1 age\_hh + \beta_2 Sex\_hh + \beta_3 Mar\_HH + \beta_4 Educ\_hh + \beta_5 \text{Size\_H} + \beta_6 Farm\_Size\_H + \beta_7 Farm\_exp + \beta_8 Incom\_H + \beta_9 Trans\_Asset\_H + \beta_{10} Memb\_Farm\text{-}Org + \beta_{11} Distan\_Mkt + \beta_{12} Time\_market + \beta_{13} Mkt\_Price + \beta_{14} Acc\text{-}Us\_Agr\_Crd + v_i \quad (3.43)$$

Table 3. 6: Description and measurement of dependent and independent variables used in second stage of DHM (Extent of Farm household's market participation)

Variables	Variable description	Measurement	Expected sign
Dependent variable			
Extent of farmers' market participation (quantity sold (kgs))			
Qty_sold	Quantity of potato sold (Kgs)	Continuous	N/A
Independent variables			
Age_HH	Age of household head	Years	+
Sex_HH	Gender of household head	Dummy 1=Male, 0=Female	+/-
Mar_HH	Marital status of household head	Dummy 1=Married, 0= otherwise	+
Educ_hh	Level of education of household head	Categorical 0= no formal education 1=Primary eduction 2=Secondary education	+
Size_H	Household size	Number of people in the household	+
Farm_Size_ HH	Total farm/land size owned by household head	Ha	+
Farm_exp	Farm household's experience in farming	Years	+
Farm_Income_H	Farm Household income	Continuous	+
Trans_Asset_H	Transport assets owned by the household	Continuous	+
Memb_Farm-Org	Whether farm household head is member of farming organization	Dummy 1=yes, 0=no	+

Distan_Mkt	Distance between household farm gate to nearest potato market (Km)	Continuous (Km)	-
Time_market	Time required between the farmer's production and the market	Hrs	-
Mkt_Price	Market price	Frw	+
Acc-Us_Agr_Crd	Access and Use of agricultural credit	Dummy 1=Yes, 0=No	+/-

3.7.4 Objective Four:

The fourth objective was to determine the factors influencing potato farmers' choice to sell to potato market outlets in Rwanda. Farmers sell to multiple channels and therefore multiple responses on types of market channels were expected. Thus, the response variable was the different outlets, including wholesalers, processors, brokers/middleman, collection centres, cooperatives, retailers, and consumers. It was anticipated that farmers would sell potato to at least one of these channels.

The choice decisions by the smallholder farmers of selling to particular market outlets respect the random utility theory whereby farmers evaluate the market outlets and select the market outlets that maximize their utilities (Baltas & Doyle, 2001). The useful econometric models that would be used to analyse the categorical choice of dependent variables are multivariate probit, multinomial logit. The studies conducted by Nxumalo *et al.(* 2019), Singh (2018) and Xaba and Masuku (2012) have used multivariate logit, multinomial logit/probit to analyse the factors affecting producer's choices of market outlets. Whereas Abate *et al.* (2019), Dlamini-Mazibuko *et al.*(2019), Kassaw *et al.*(2019), Melese *et al.*(2018), Sori and Aman (2017), Tarekegn *et al.*(2017) and Tura and Hamo (2019) have used multivariate probit to analyse the factors affecting farmers' choice of market outlets.

However, the farmers' choices are based on the cost to be incurred and expected benefits from selling to the market outlet. In this study, smallholder potato farmers have possibilities of choosing simultaneously one or more market outlets among the seven market outlets (consumers, retailers, collection centres, cooperatives, brokers, processors and wholesalers). Therefore, the choice decision by farmers is inherently a multivariate decision. Multivariate probit model is a simultaneous system of several binary probit of M-dimensions. It models

the influence of a set of explanatory variables on choice market channels, while allowing for the potential correlations between unobserved disturbances, as well as the relationships between the choices of different market channels (Belderbos *et al.*, 2004).

Consequently, using multinomial models (MNM) for market outlet choice would not be viable because the farmer would be limited to choose only one market outlet from the set of mutually exclusive and collectively exhaustive choices. In addition, MVP is preferred over MNM because of the independence of irrelevant alternative assumptions and relevant risks of choosing one outlet can be affected by the relative risk of choosing the other outlet (Greene, 2002). Multivariate Probit (MVP) is an appropriate model for multiple choice problems for this study to estimate numerous correlated binary outcomes that capture the influence of a set of independent variables on each of different choices of market outlets. The farmer household's choice decision to sell to one or more market outlets is led by the farmers' willingness to maximize their expected utility than otherwise (Fafchamps & Hill, 2005) and is conditioned to a number of factors like socioeconomic, institutional, production and market related factors (Arinloye *et al.*, 2015; Tarekegn *et al.*, 2017).

Consider the i^{th} farmer household ($i=1,2,3\ldots\ldots N$) facing decision problem of whether or not to choose the available market outlets $(k=1,2\ldots\ldots m)$. Let U_k represents the benefit of famer to choose the k^{th} market outlet where k denotes the choice of consumers (Z_1), retailers (Z_2), collection centres (Z_3), cooperatives (Z_4), brokers (Z_5), processors (Z_6) and wholesalers (Z_7).

The potato farmer household i^{th} has a set of alternatives ($k=1, 2, 3,.., m$) which provide a certain level of utility U_{ik} from each alternative.

The model is written as: $Z_{ik}= X_{ik}\beta_{ik}+\varepsilon_{ik}$ …… (3.44)

Where, ($k=Z_1, Z_2, Z_3, Z_4, Z_5, Z_6$ *and* Z_7) representing the dependent variables of potato market outlets to be selected by the i^{th} farmer household ($i= 1,2,\ldots N$). The X_{ik} is a 1*k independents variable that influence the choice of market outlet decisions, β_{ik} is k*1 vector of unknown parameters to be estimated and ε_{ik} are the error terms distributed as multivariate normal. The farmer decides to choose k^{th} market outlet if $Z^*_{ik} = U^*_k - U_0 > 0$ where U_0 denotes the utility to the farmer from not choosing none of the market outlets and U_k represents the utility of using the k^{th} market outlet. The benefit Z^*_{ik} that a farmer derives from the choice k^{th} market outlet is the latent variable determined by observed and unobserved explanatory characteristic. However, the dependent variables are polychotomous variables indicating that farmer household may sell potato at more than one relevant market outlet.

The econometric approach for this study was by using the indicator function; the unobserved preferences translated into the observed binary equation for each choice as:

$Z_k^*= X_k\beta_k+\varepsilon_k$ $Z_{ik}=1$ if $Z^*_{ik}>0$, $Z_{ik}=0$ otherwise, for k= Z_1, Z_2, Z_m…….. (3.45)

$Z_1^* = X_1\beta_{1+}\varepsilon_1 Z_1=1$ if $Z^*_1>0$, $Z_1=0$ otherwise

$Z_2^* = X_2\beta_{2+}\varepsilon_2 Z_2=1$ if $Z^*_2>0$, $Z_2=0$ otherwise

$Z_3^* = X_3\beta_{3+}\varepsilon_3 Z_3=1$ if $Z^*3>0$, $Z_3=0$ otherwise

….. …..

$Z_7^* = X_7\beta_{7+}\varepsilon_7 Z_7=1$ if $Z^*_7>0$, $Z_7=0$ otherwise

In the MVP model, the error terms jointly follow a multivariate normal distribution (MVN with zero conditional mean and variance normalized to unity where (U_1, U_2,…..U_m) ~MVN (0, Ω) and the symmetric covariance matrix of Ω is given as:

$$\Omega = \begin{bmatrix} 1 & \rho x_1x_2 & \rho x_1x_3 & \rho x_1x_4 & \rho x_1x_5 & \rho x_1x_6 & \rho x_1x_7 \\ \rho x_2x_1 & 1 & \rho x_2x_3 & \rho x_2x_4 & \rho x_2x_5 & \rho x_2x_6 & \rho x_2x_7 \\ \rho x_3x_1 & \rho x_3x_2 & 1 & \rho x_3x_4 & \rho x_3x_5 & \rho x_3x_6 & \rho x_3x_7 \\ \rho x_4x_1 & \rho x_4x_2 & \rho x_4x_3 & 1 & \rho x_4x_5 & \rho x_4x_6 & \rho x_4x_7 \\ \rho x_5x_1 & \rho x_5x_2 & \rho x_5x_3 & \rho x_5x_4 & 1 & \rho x_5x_6 & \rho x_5x_7 \\ \rho x_6x_1 & \rho x_6x_2 & \rho x_6x_3 & \rho x_6x_4 & \rho x_6x_5 & 1 & \rho x_6x_7 \\ \rho x_7x_1 & \rho x_7x_2 & \rho x_7x_3 & \rho x_7x_4 & \rho x_7x_5 & \rho x_7x_6 & 1 \end{bmatrix} \text{……..(3.46)}$$

In this case, ρ_{im} denotes the error terms' pairwise correlation coefficient, which relates to just any two choice equations that have to be approximated. The market outlet choices that are along the farmer household's decision involved in alternatives are represented in model as: $\rho x_1, \rho x_2, \rho x_3, \rho x_4, \rho x_5, \rho x_6$ *and* ρx_7 for households who choose wholesalers, processors, brokers, collection centres, retailers or consumers to sell potato.

The assumption is transformed into an MVP model which represents a joint choice decision for a highly relevant market. This specification with non-zero off diagonal elements enables for correlation across error terms of several latent equations, and that represents unobserved characteristics that influence the selection of the alternative outlets. According to the formula developed by Cappellari and Jenkins (2003) the log likelihood function is given by: $\ln L = \sum_{i=1}^{N} \omega_i \ln \Phi(\mu_i, \Omega)$ ……..……...(3.47)

Where ω is an optional weight for the observation i and Φ_i is the multivariate standard normal distribution with arguments μ_i and Ω where μ_i can be denoted as:

$\mu_i = K_{i1}ß_1x_{i1}, K_{i2}ß_2x_{i2}, \ldots\ldots. K_{im}ß_mxi_m,$ with $K_{ik} = 2y_{ik} - 1$, for each i, k = 1, . . ., 3.

Matrix Ω has constituent elements Ω_{mk}, where Ωim =1 for m = 1, 2…..m

$\Omega_{21} = \Omega_{12} = K_{i1}K_{i2}\rho_{21}$; $\Omega_{m1} = \Omega_{1m} = K_{im}K_{i1}\rho_{m1}$; $\Omega_{m2} = \Omega_{2m} = K_{im}K_{i2}\rho_{m2}$ .....(3.48)

The dependent variable (market outlet selection) is both categorical and discrete variable with *M* possible market outlets. Those constitute the paths that the farm households intend to take for supply to the end consumers. Farmers are free the best place for selling their produce based on variety of criteria. Therefore, for maximizing the expected utility, the farmer is likely to select multiple market outlets, at the same time. Resulting to this, there is some overlap, and many farmers sell to more than one market outlet. The Multivariate probit model considers the potential interdependence in market outlet choices and possible correlation in the choice of alternative outlets.

Table 3. 7: Description and measurement of dependent and independent variables used in Multivariate probit model

Variables	Variable description	Measurement	Expected sign
Dependent variable			
MktOutlet	Choice decision of market outlet where production is sold	Categorical choice 0=Wholesalers 1= Processors 2= Brokers/Middleman 3= Collection centres 4= Cooperatives, 5= Retailers 6= Consumers	
Independent variables			
Age_HH	Age of household head	Years	+
Sex_hh	Sex of the household head	Dummy 1=male, 0=female	+/-
Mar_HH	Marital status of the household head	Dummy 1=Married, 0 otherwise	+
Educ_hh	Level of Education of household head	Categorical 0= no formal education 1=Primary	+

		2=Secondary	
Size_ H	Household size	Number of people in household	+
Farm_Size_ H	Total farm/land size owned by household head	Continuous (Ha)	+
Farm_exp	Farm household's experience in farming	Years	+
Farm_Income_H	Farm Household's total annual income	Continuous (Frw)	+
Memb_Farm_Org	Membership of household head to farming organization	Dummy 1=yes, 0=no	+
DistanMkt	Distance between household farm gate to nearest potato market (Km)	Continuous (Km)	-
Trans_Asset_H	Transport assets owned household head (facilities equipment)	Dummy 1=yes, 0=no	+
Trust	Trust between Farmer and buyer	Dummy 1=Yes, 0=No	+/-
AccMktInf	Access to market information	Dummy 1=Yes, 0=No	+
Train_Ptt_HH	Household head received training in potato production practices	Dummy 1=yes, 0=no	+/-
Cont_Exten_Off	Household head had contacts with the extension officer	Dummy 1=Yes, 0=No	+/-

3.7.5 Objective five:

The fifth objective was to evaluate the effects of access to potato market on farm households' livelihood. Maximum utility and Farm Gross marketing margin modes have been used to assess the effects of access to potato market on household income. Potato farmers' choice to access to agricultural loan was based on the assumption of expected utility maximization. Either borrowing or non-borrowing decisions depended on the farmer household's socioeconomic and demographic variables. Based on the maximum utility theory, PSM and ESR models; effects of access and use of agricultural loan to increase the farm gross marketing margin / price to potato farmers in Rwanda was measured.

Farmer maximized profits from the sale of potato products after controlling the constraints like institutional, market and financial constraints. This is represented as:

Max. Profit: $\pi^{*}=\pi^{*}(p_a, x, y, \mathrm{w}, z)$…… (3.49)

x= socioeconomic constraints which include farmer characteristics, farm characteristics and farming investment cost

y= Institutional constraints and these include costumer search costs, search for market information, access to infrastructure and market selection trainings.

w= financial constraints which include amount of credit, loan requirement, cost of borrowing, annual interest rate, collateral required, capacity to pay back the loan and financial standard measurement.

z= market constraints which include distant to market, market organisation, quantity demanded, quantity sold and selling price and market standard measurement.

Where:

$\pi=\beta_j x_j + \beta_k x_k + \beta_n x_n + \beta_m x_m \ldots + \varepsilon$ …….……. (3.50)

where:

π=Profitability

x_j=socioeconomic constraints

x_k=institutional constraints

x_n=financial constraints

x_m= market constraints

To analyse the contribution of the agricultural financing approach on farm household income, the study has used farm gross margins analysis model (GMA). This farm gross margin facilitated to know the contribution of agricultural loan on the farm gross margin.

The model is suitable estimator of economic gains from potato production. The model was used to compare the difference between the gross margins of farmers with and without agricultural loan. The gross margin is obtained by subtracting the variable costs (cost of production) from income or sales revenue. The following formula was applied:

Farm gross margin= TR-VC …….. (3.51)

High gross margin reflected high contribution of agricultural finance to potato profitability. However, the GMA would not measure the farm net profit as it did not consider the total fixed costs.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presented the results and discussed the findings of the study on effects of agricultural value chain financing on potato productivity and market access on farm households' livelihood in Musanze and Nyabihu districts, Rwanda. The socioeconomic attributes of sampled farm households were described using descriptive statistics. Econometric models were used to determine the factors influencing smallholder potato farmers' decision to participate to agricultural value chain financing, to evaluate the effects of agricultural value chain financing on potato productivity, to determine the factors influencing smallholder potato farmers' access to market, to determine the factors influencing potato farmers' choice to sell to particular potato market outlets and effects of agricultural value chain financing on smallholder potato farm households' livelihood. A total of 585 sample comprising 275 (47.01%) participants to agricultural loans and 310 (52.99%) non-participants were selected from smallholder potato farmers in the study areas. Data were processed using MS EXCEL, SPSS and STATA packages.

4.2 Socioeconomic characteristics of sampled potato farmers

Table 4.1 showed that the socioeconomic characteristics of farmers were very important factors in the farmers' decision to participate in agricultural loans scheme and efficiently allocate their resources.

4.2.1 Age of the household head

The mean age of sampled potato farmers was 41.49 years ranging from 26 years and 63 years. Non-participants had an average age of 41.49 years, while participants had an average age of 41.71 years. This implied that potato farmers were in their productive years. The age of household head was an important factor in decision making process whereby the older farmers have more experience in farming than the young farmers. The age might influence either positively or negatively the decision of the farmer to participate or not to participate in agricultural financing to improve the wellbeing of their family members. The mean average of sample households is illustrated in Table 4.1. The table also demonstrated that farmers' participant to agricultural financing had more family members (5.05) than farmers' non-participant to agricultural financing (4.89). This implied that participants might have advantages of family labour in potato production than non-participants.

4.2.2 Household size of the household head

Table 4.1 showed also that farmers' participant to agricultural financing had more members (5.05) than farmers' non-participant to agricultural financing (4.89); this implied that participants might had advantages of family labour forces to employ in potato production than non-participants. The mean household size of potato farmers in study area was 4.96 members per family which does not deviate much from the average household size of 4.3 members at national level (NISR & MINECOFIN, 2014).

4.2.3 Sex of the household head

The descriptive statistics of potato farmers presented in Table 4.1 showed that out of 585 interviewed 61.54 % of sampled households were male headed while 38.46 % were female headed. About 35.48 % and 64.52 % of the non-participants were respectively female and male headed households, while 41.82 % and 58.18 % of the participants were respectively female and male headed households. This shows the domination of male in decisions relating to potato production.

4.2.4 Marital status of the household head

Table 4.1 showed that out of 585 interviewed households, 87.86 % of the sampled farmers were married, 12.14 % were unmarried (widow, single separated and divorced). The married non-participants were 90.00 % while the married participants were 85.45 %. The high %age of married non-participants may delay the decision making. As far as agricultural financing is concerned, there is always a need for the consent of spouses.

4.2.5 Household head's education level

As illustrated in Table 4.1, from 585 households interviewed, 195 (33.33 %) of sampled farmers attended high schools while 310 (52.99 %) attended primary education and 80 (13.68 %) had no formal education. Among those who attended high school, the non-participants were 76 (24.52 %) while the participants were 119 (43.27 %). However, the low level of education of non-participants farmers had a negative impact on participating and utilizing the agricultural value financing. According to NISR (2012), the 2012 Rwanda Population households Census (RPHC) showed that 68 % of Rwandan population aged 15 and above were literate, with 12.4 % attended secondary education. This implied that the level education of potato farmers in the study area was considerably improved comparatively to the average of persons with secondary education level in Rwanda. The results confirmed with the findings of different researchers who found that the education contributes positively to

credit worthiness of the farmers (Arene, 1993; Enimu *et al*., 2017) and to adopt the agricultural technology to produce more (Sebatta *et al.*, 2014) and decide on the access to the agricultural financing, than non-educated farmers.

4.2.6 Farm size

The mean farm size under potato cultivation for participants and non- participants to agricultural loans were different. The farmers involved in the survey were smallholder potato farmers with the mean farm size for non-participants was 0.3516 Ha while mean farm size for participants was 0.6473 Ha, the pooled mean farm size was 0.4957 Ha under potato cultivation. The farm size was hypothesized to have a positive effect on smallholder potato farmers' decision on using financial loans in his/her production processes. Farmers with larger proportions of cultivated lands were likely to get loans and give the lands for securing their loans from financial institutions.

4.2.7 Farming Experience in potato (Years)

From the interviewed sample, 4.1 % were below 1 year of farming experience, 11.6 % were between 1-5 years of potato farming experience while 84.2 % were above 5 years of potato farming experience. In Rwanda, financial institutions do not have much experience in financing agricultural sector. Therefore, the longer experience in farming might increase the abilities of a farmer to whether to opt or not for the agricultural loan and increase their creditworthy from lending institutions.

Table 4.1: Socioeconomic characteristics and farm characteristics of sampled farm households

Variables		Non-Participants N=310		Participants N=275		Pooled sample N=585	
		Mean	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Age (years)		41.48547	8.767949	41.70545	8.631368	41.4855	8.76795
Household size		4.893548	1.467542	5.050909	1.525079	4.96752	1.495646
Farm size		0.3516	0.64531	0.6473	0.80778	0.4957	0.74051
Variables		**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Sex of the respondent	Female	110	35.48	115	41.82	225	38.46
	Male	200	64.52	160	58.18	360	61.54
Marital status of farmers	Single	7	2.26	14	5.09	21	3.59
	Married	279	90.00	235	85.45	514	87.86
	Widow	23	7.42	25	9.09	48	8.21
	Separated	1	0.32	0	0.00	1	0.17
	Divorced	0	0.00	1	0.36	1	0.17
Education	No formal education	54	17.42	26	9.45	80	13.68
	Primary education	180	58.06	130	47.27	310	52.99
	Secondary	76	24.52	119	43.27	195	33.33

	education						
Farming Experience in potato (Years)	Below 1	21	3.6	3	0.5	24	4.1
	Between 1-5	44	7.5	24	4.1	68	11.6
	Between 6-10	83	14.2	89	15.2	172	29.4
	Between 11-15	93	15.9	109	18.6	202	34.5
	Above 15	69	11.8	50	8.5	119	20.3

4.2.8 Sources of household income

Though some of all respondents exercised agricultural and other economic activities (Figure 7), the main source of income for 440 (75.2 %) was agriculture and livestock, 77 (13.2 %) combined agriculture and employment in public or private employment. Potato farmers run small business and were involved in handcraft activities at 37 (6.3 %) and 21 (3.6 %) respectively. However, the farmers who participated and utilized agricultural value chain financing had more farm activities than the farmers who did not use agricultural financing. This explained the essence of the agricultural financing approach for the economic growth of farmers. Nonetheless, almost 84.3 % of these farm household head had more than 15 years in cultivating potatoes but with little training in potato practices (38.1 %), as illustrated in table 4.1.

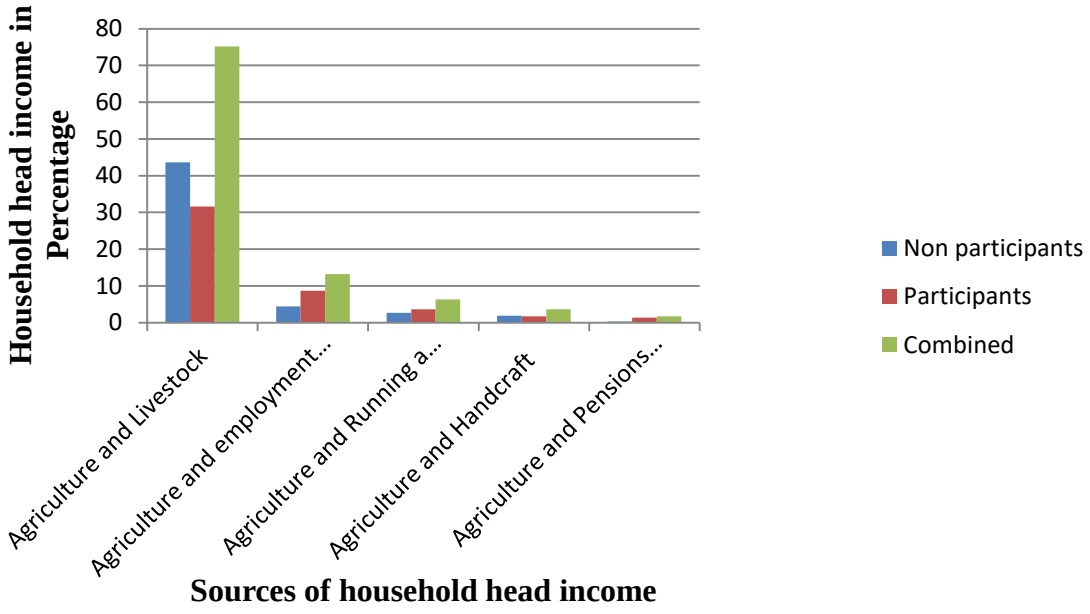

Figure 4.1: Sources of household head income in Percentage

4.3 Factors influencing potato farmers' decision to participate to the value chain financing in Rwanda

Probit model was used to determine the factors that influencing potato farmers' decisions to participate and use the value chain financing in Musanze and Nyabihu District.

The factors were found through regression of farmer' use of agricultural value chain financing (P_{it} (0,1)) versus sex, age, marital status, household size, education, household income, asset household (Land), asset household (house) asset household (livestock), asset household (transport equipment), total land size, farmers' membership to farming organizations , training in potato practices, farming experience of the household head and distance to markets. Table 4.2 shows the findings of statistical analysis of the independent variables that influence farmers to use value chain financing.

The model showed the variables that influence the farmers' decisions to participate to agricultural financing at three levels of significance 1 %, 5 % and 10 %. Sex and age were found to be significant at 1 % and 10 % significance levels respectively. The findings have also revealed that sex and age are very important variables that may establish the individual characteristics of different decision makers. Sex had a negative and highly significant relationship with participation and use of agricultural finance. This is consistent with the findings of Abdul-Hanan *et al.* (2015) who discovered that gender was significantly and negatively related to farm households' decisions to access agricultural credit. This indicated that female headed households were more likely to receive agricultural loans than male headed households. Given that the government and most development finance institutions focus on women, they developed more financial packages that might be factors for women entrepreneurs to improve in agricultural value chain development. The findings were consistent to those of Akudugu (2012) who found that though female are considered disadvantaged, they are creditworthy and more likely to seek credit than their male counterparts.

With regards to age, the findings revealed that farmers' willingness to participate in and use agricultural loan increased with the age of the farm household head. This finding is understandable, given that the active age group is important factor for decision making. banks and other financial institutions were more likely to make loans to mature borrowers with ability to use and repay the loan. The finding is in line with the findings of Kosgey (2013) and Abdul-

Hanan *et al.* (2015) who discovered that farmers' age influences their access to agricultural loan. The study also discovered that the older farmers were expected to have more experiences in farming, much information about various sources of finance and more credibility with loan providers than younger farmers. Marital status was negative, implying that unmarried farmers (single, separated, divorced or separated) were more likely to participate to agricultural financing than the married counterparts. A married household may not unilaterally decide to participate to agricultural financing without the consent of the partner. Despite the Rwandan government's priority for social and labour equality between spouses, female rights to household property remain limited and thus limiting access to and use of credit. notably in Musanze and Nyabihu Districts, where husbands hold social, political, and decision making power over household resources

Even though the government of Rwanda prone for social and labour equality between spouses, the female right on household property is still limited and thus limited access and use of credit. Particularly in Musanze and Nyabihu districts where the husbands have social, political power and domination in decisions affecting the household resources. A significant and positive relationship was also observed between household income and participation and use of agricultural financing. This meant that in the study area farmers with higher incomes were more likely to participate and use agricultural finance than those with lower incomes. Farmers with higher incomes were better off socially and economically and they were more creditworthy to loan providers compared to farmers with lower incomes. Moreover, banks and other financial providers may be willing to give more loans to wealthier farmers who are economically productive and have lower risks of defaulting (Asante *et al.*, 2017).

The findings revealed a positive and significant relationship between education and participation to agricultural finance. Farm household head with a higher level of education has a better access to updated information on cost effective and efficient ways of production methods. It improves farm households' abilities to adopt more advanced technologies and crop management techniques for increasing productivity (Rosegrant & Cline, 2003).

High educated farmers have capacity to find and read financial market signals and find the less scaring signals to request for loan compared to low educated farmers. Educated famers have a clear plan on how to increase the investment capital in potato production and hence participate

and use agricultural financing. The result of the study was consistent with Diagne and Zeller (2001) who found a positive relationship between education level of the household head with making informed decisions about borrowing.

The result revealed also positive and significant (at 1 %) relationship membership to farming organizations with the probability of a farmer to participate to agricultural loan. The idea behind joining the farming association was to increase the credit worthiness with financial providers.

Table 4. 2: Probit estimates for factors influencing potato farmers' decision to participate to the value chain financing

Variable	Coef.	Robust Std. Err.	z	P>z
Sex of household head (1=Male, 0 otherwise)	-0.405***	0.124	-3.270	0.001
Age of household head	0.014*	0.008	1.800	0.072
Education level				
Primary education	0.303*	0.177	1.710	0.087
Secondary Education	0.724***	0.196	3.690	0.000
Marital status ((1=Married, 0 otherwise)	-0.388**	0.178	-2.180	0.029
Farming experience	-0.098**	0.050	-1.970	0.049
Household size	0.054	0.040	1.350	0.176
Log household income	0.388***	0.080	4.880	0.000
Farm size	0.008	0.085	0.100	0.923
House assets (1=Yes, 0 otherwise)	0.552	0.369	1.490	0.135
Livestock assets (1=Yes, 0 otherwise)	0.157	0.120	1.310	0.192

Transportation assets (1=Yes, 0 otherwise)	0.196	0.289	0.680	0.497
Membership to farming organizations (1=Yes, 0 otherwise)	0.444***	0.127	3.500	0.000
Training in Potato practices (1=Yes, 0 otherwise)	0.003	0.126	0.020	0.981
Distance to the market	0.024***	0.005	4.420	0.000
Constant	-6.584***	1.136	-5.790	0.000

*, ** and *** denotes that the coefficients are significant at 10, 5 and 1 % levels respectively.

This implied that when farmers adhered to farming associations, were not required to provide collateral for the loans contracted with the loan providers. Members of the farming associations jointly served as guarantee for each other. This was consistent with Akudugu (2012) and Lukytawati (2009) who found that membership to solidarity association is fundamental for farmers to request for loan.

Surprisingly, farming experiences was found significant at 5 % but negatively related to participation and use of agricultural loan. This implied that the probability of farmers to use credit decreased with the increase in farming experience. Though contrary to study expectation, the result was reasonable as accumulated income from previous production is reinvested to purchase inputs needed. Therefore, the increased income accumulation would result in the decreased willingness of the farmer to request for investment loan. However, the finding contradicted with the find of Kgowedi *et al.* (2002) who associated the increased credit with increased income generation. Result on distance to market was significant at 1 % and positive with influence of participating to agricultural financing. The significant relationship between distances from the farm gate to market implied the importance of additional financing for farmers operating further away from the market to economically exploit the economies of scale associated with large land holdings. Larger land holdings from urban areas are less likely to be converted into commercial plots (urban houses or infrastructure), but very attractive to lenders as less risk collateral.

4.3.1 Sources of agricultural finance for potato value chain activities

Potato farmers' participation and use of agricultural value chain financing facilitated operational and capital investment to attain high productivity. They used the external financing models which consisted of loans from the existing financial institutions. Figure 8 presents the most lending models used in the area of the study.

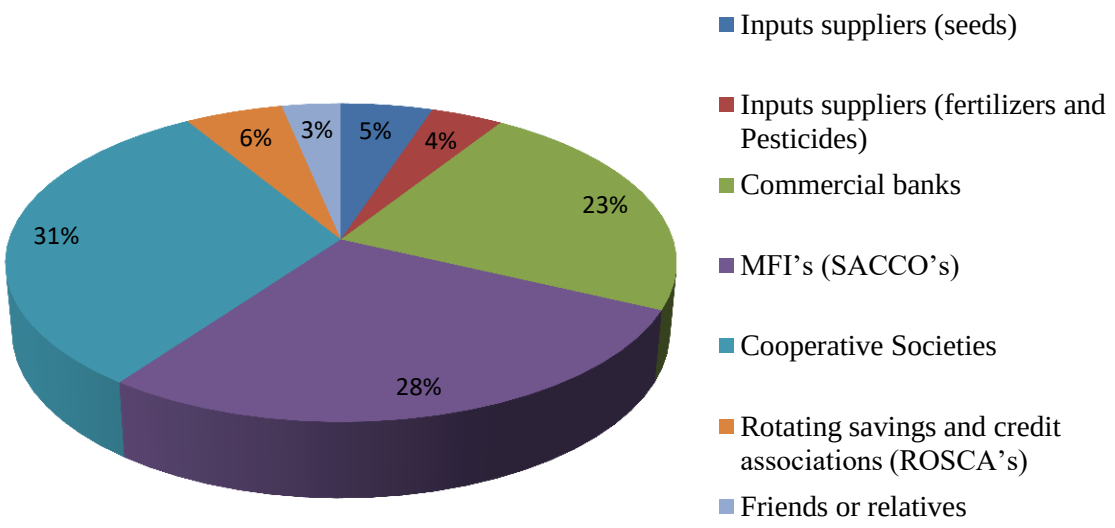

Figure 4.2: Sources of agricultural finance to potato farmers in the study area/ agricultural financing modes in the study area

Both Formal and informal baking and financial institutions made significant contributions to the potato farmers' activities, either in form of cash or inputs.

The study identified seven sources of finances for potato activities distributed as follows: cooperatives 31%, Micro Finance Institutions (SACCO's) 28%, Commercial Banks 23%, Rotating Savings and credit association (ROSCA's) 6%, Friends or relatives 3%, inputs suppliers (seeds) 5% and inputs suppliers (Fertilizers) 4%. Potato farmers were free to get loans from any of the above sources with respect to their abilities to fulfil the borrowing requirements.

Inputs on credit from inputs suppliers and cooperatives

The discussions with the leaders of some farming organizations and other keys informant, the loans received were either in- kind loan (quality seeds or fertilizers) or in cash (Frw) and got technical assistance where needed. Farmers got advances of fertilizers and chemicals which they paid in cash from the sale of potato harvested. In-kind received from both inputs dealers and their respective cooperatives were around 18.2 % of total credit received. The in-kind loans were paid at zero % interest rate.

Cooperative societies' loans

With shortage of finance in their production farmers have received 81.8 % of the total loans in Cash. 31% of the famers used credit from their respective cooperatives and agreed to pay after harvest (within 4 months period) at 10-15% per month. Though farmers appreciated this financing model, it is very expensive than approaching microfinance institutions or Banks.

MFI's and SACCO's

The study revealed that 28 % of farmers got loans from Microfinance institutions and Sector SACCO's (4 "Umurenge" SACCO's). MFI and SACCO's disbursed the total amount requested to smallholder farmers in cash for being freely used in production at the interest rate of more than 20 % per annum (2.5% per month).

Commercial banks loans

The study revealed that 23 % of farmers received loans from commercial banks to purchase inputs and expand their production. The banks and financial institutions involved in the process of providing loans to farmers are banks (BPR, BK, KCB, Urwego Opportunity Bank and Unguka Bank Ltd). To facilitate farmers to access financial loans, Bank of Kigali (BK) has launched two financial products extended to Farmers, Smart Nkunganire system (SNS) and "IKOFI" (Wallet) products which have played role for farmers to improve the agricultural finance and significantly boost the agricultural productivity in Rwanda. Under a mobile based programme "MobiGrow" product, KCB facilitated many smallholder potato farmers to access to affordable funds and technical advisor services aimed at boosting their productivity.

However, the study found that many of these commercial banks have difficulties to differentiate farmers from other customers. Though various studies have seen potentials of potato for reducing poverty in Rwanda, many commercial banks have no financial products or interest rate particularly designated to potato farmers. The interest rate for both agricultural and trading activities from commercial banks is ranging between 15-20 % annum.

Rotating Saving and credit associations (ROSCA's)

Like in other developing countries, 6 % of interviewed potato farmers organize and use the self-help financing and saving groups known as rotating saving and credit associations (ROSCA's) to accumulate investments needed for their production. Though farmers access the finances, participation to ROSCA's requires farmers to be creditworthiness and this remains a big challenged to rural farmer with low capacity of using huge investment in potato production. Another risk is the viability of the farmer groups who eventually need an assistance to manage huge amount of money collected. Farmers staying at relatively far from the financial institutions' premises have demonstrated their tendencies of saving their income with ROSCA's. The longer the distance to formal financial credit markets from farmers, the more difficult and costly it will be to transact with them. This was frequently observed from the non-participants to agricultural financing where the interest rate ranges between (3-10 % per month or 36-120 % per annum).

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Friends or relatives

Asides from the above sources of finances, 3% of interviewed potato farmers use the money borrowed from their friends or relatives. Farmers have their own organization of lending money or seeds to their counterparts, which they pay on due time.

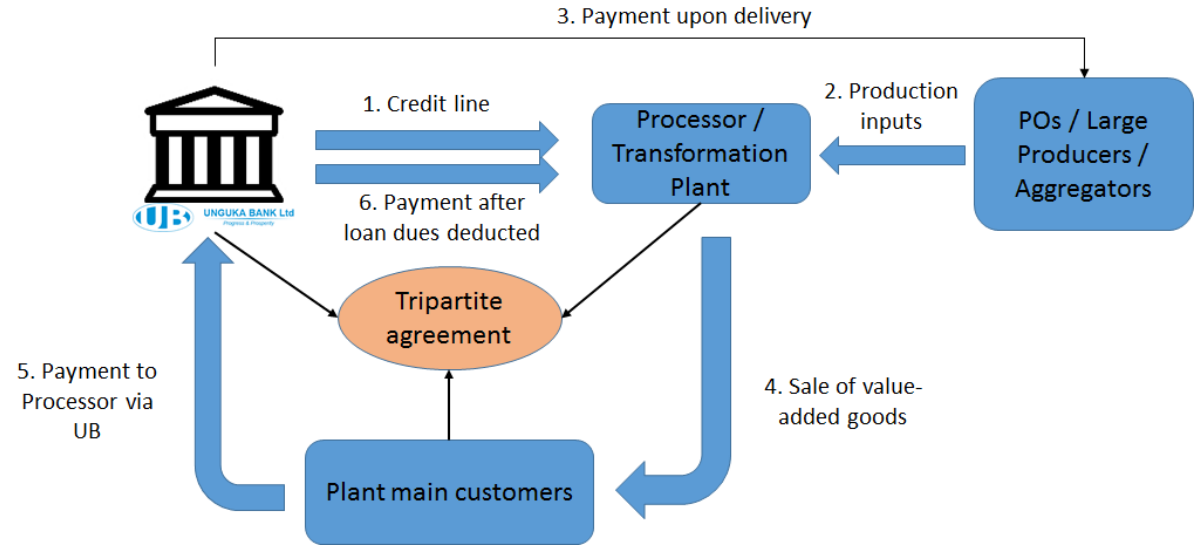

Figure 4.3: Example of value chain financing in Unguka Bank Ltd

This revealed one of the advantages of financing of inputs to potato farmers to reduce the farmers' transaction costs since interests is embedded in the price(Winn *et al.*, 2009).

4.3.2 Potato value chain financing

The figure 4.4 highlights the potato value chain, chain actors, chain activities and level of financial institutions' financing in the chain. The figure summarises the potato value chain into four main processes that include: inputs supply, production, potato trading or marketing and potato consumption.

Inputs supply chain: the chain comprises mainly of the following chain actors: research institutions, inputs suppliers (private and public institutions or NGO's) all engaged directly or indirectly in provision of agricultural inputs through marketing or distribution to farmers. The most important inputs for potato production are potato seeds, fertilizers, fungicides and pesticides as well as other chemicals needed by potato farmers. Under this chain, the inputs suppliers are financed their own saving, Relatives and friends, Government subsidy for inputs and Commercial banks (Bank, SACCO's or other financial provides).

Production: the chain comprises mainly of Smallholder farm households and Farm organizations who use the potato seeds from either certified seed supplier, retained from previous harvest, purchased from neighbours or purchased from local markets. Potato producers are financed from their Own savings, cooperative societies, relatives and friends, government Inputs subsidies, rotating saving and credit associations (ROSCA's) and Financial

institutions (Bank, SACCO's. Due to lack of guarantees, the actors of this chain encounter difficulties of obtaining financing from commercial banks. financed by commercial banks due the lack of collaterals.

Processing: the chain comprises the agro processing industries which produce crips and French fries or other products as form of value addition for potatoes. In study area, there two processing industries: Nyabihu potao Company Ltd located in Nyabihu Dostrict and Holland Fair foods Limited (Winnaz) located in Musanze district. Though Rwandans are among the best consumers of fresh potatoes, the demand for processed potatoes in form of crips and French fries is rapidly increasing in urban areas. Being market-driven, actors in this chain obtain more finance from commercial banks.

Trading/marketing: the chain comprises of all actors that package, transport, distribute and sell potatoes to consumers. These include collection centres, marketing cooperatives, brokers, transporters, marketing agencies, wholesalers and retailers. Majority of producers sell potato to those categories of traders with respect to the prices provided. The actors in this chain obtain much financing from Commercial banks.

Consumption: this chain comprises of households and institutions (restaurant, hotels, and schools) that consume potatoes continuously. The potato consumption per capita in Rwanda is between 0.100 and 0.125 metric tons per person per year with higher consumption rate in some areas of Northern and Western provinces where the production of potato is very intensive. (FOASTAT, 2022).

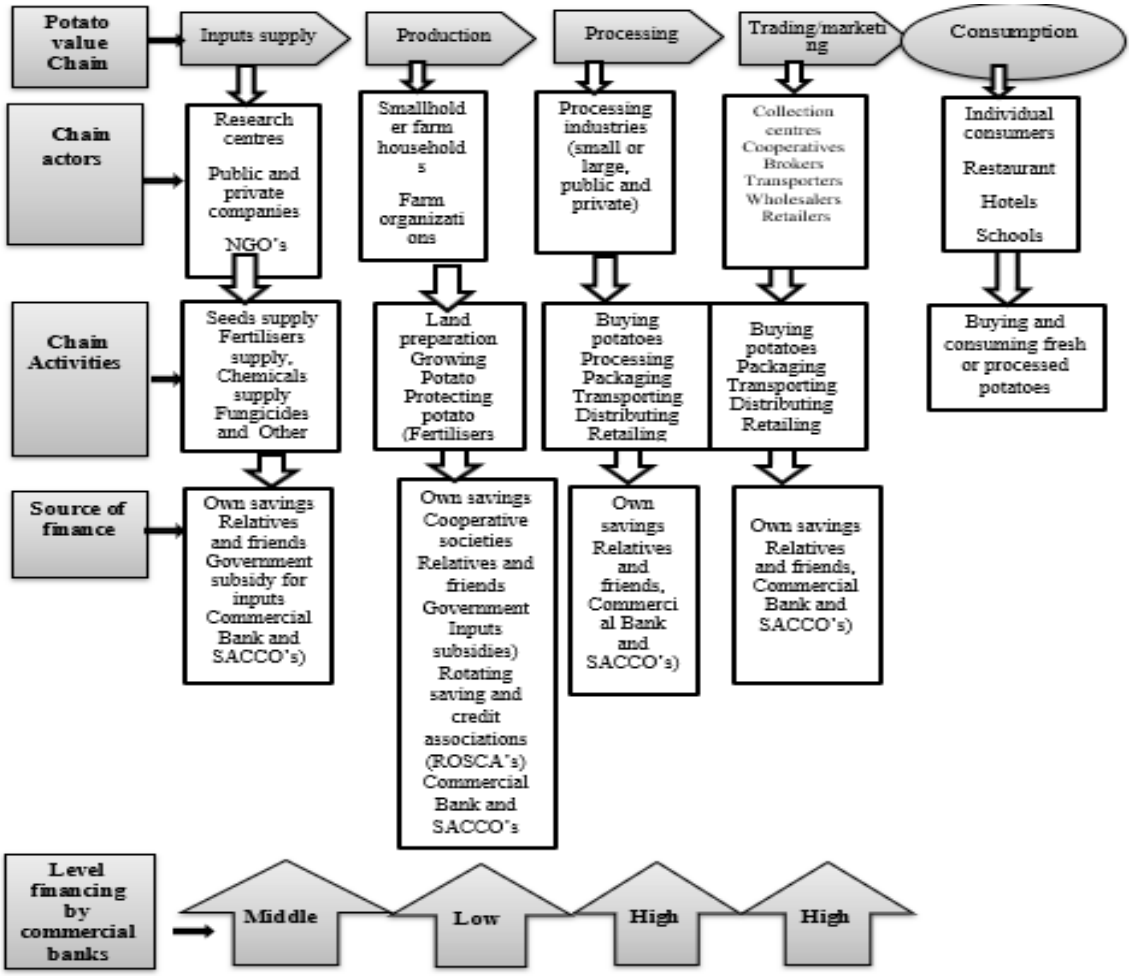

Figure 4.4: Potato Value chain mapping and value chain financing in Rwanda.

However, in Rwanda all actors in potato value chain, finance is a critical factor that hinders its success.

Table 4.3: Loans obtained and used in potato production per District (Frw)

Amount of Loan	District		Total	%e
	Musanze	Nyabihu		
Less than 100000	28	36	64	23.27
100001-200000	37	20	57	20.73
200001-300000	19	26	45	16.36
300001-400000	8	9	17	6.18
400001-500000	19	19	38	13.82
More than 500000	20	34	54	19.64
Total	131	144	275	100.00

As presented in Table 4.3, from the 47.01 % of farm households who used the agricultural loan used in potato production, 23.27 % used less than 100000 Rwandan Francs of the total loan obtained , 20.73 % used between 100001-200000 Rwandan Francs of the total loan obtained; 16.36 % used between 200001-300000 Rwandan Francs of the total loan obtained; 6.18 % used between 300001-400000 Rwandan Francs of the total loan obtained; 13.82 % used between 400001-500000 Rwandan Francs of the total loan obtained while 19.64 % used more than 500000 Rwandan Francs of the total loan obtained. Though the farmers used agricultural loans, the results also revealed the proportional amount of money smallholders were willing to borrow to invest in potato production.

4.3.3 Modes and requirements of borrowing

In Rwanda, smallholder farmers are the victims of lack access to financial products and services. Farmers need to fulfil financial requirements before being served by different sources of agricultural finance (Table 4.4).

Collateral,

As per the table above, the conditions with high mean were considered to be essential conditions for farmers to access agricultural financing from the loan's providers. The study showed that the collateral (mean statistic = 3.1018) was much higher than others. Most of the collaterals required were physical tangible assets such as land and houses titles. The collaterals were proven to be very important for MFI's and SACCO's loans (75 %), commercial bank loans (60 %) and cooperatives loans (53 %). Owning land and house titles explained the farm household' social and wealth status, such household was more likely to access to the agricultural loan than others.

Member of any registered cooperative,

As far as value chain financing is concerned, farmer organizations/associations played key role in the financing system. Farmer member of a registered cooperative/organization/association (mean statistic = 2.7018) was likely to access credit than others. Farmers without collaterals were backed by the cooperative for the amount of loan they contacted with the lenders**.** Membership to farming organizations was very important for the loan offered by cooperatives (73 %) and loan offered by Microfinance institutions (45 %).

Agreement with spouse,

Agreement between spouse (mean statistic =2.5527) was considered very important requirement for commercial bank loans (48 %), MFI's and SACCO's loans (41%) and cooperatives loans (34 %). Household members need to behave like one family, otherwise a unitary decision in investment explain dictatorship (Mattila-Wiro, 1999) which might lead to mismanagement of household property. The women were more involved in farming activities and therefore agreement between spouses on loan use would be more likely to increase potato productivity. This was obvious because the constitution of Rwanda offers equal right to the spouses. This implied that the household investment decision was collectively made by spouses or in collaboration with other household members (Alderman *et al.*,1995).

Farmer credit repayment records,

The eligibility to receive agricultural loan, potato the farmer was not only measured by the ownership of land or house titles but by the repayment records (mean statistic = 2.3236), which makes the credit worthiness of the farmer. Like other business borrowers, a farmer who needed credit undergone an in-depth evaluation of his/her credit repayment report to decrease the likelihood of default loans and provide the lender with credible information about the of the farmer's ability to repay the loan. However, with respect to the value chain financing, the agricultural lenders should not rely on the individual farmer creditworthiness rather on the agreement between the bank, buyer and farmer.

Profitability of the farm and farmer management abilities,

The financial lenders took into consideration the information about the financial records from the farmer's exploitation to measure his/her payment abilities. The profitability of the farming (mean statistic =2.1782) was evaluated through the brief information about the income earned from previous exploitation. The more earnings explained the profitability of farm and the farmer's management abilities (mean= 1.9455) to generate cash and pay from the sale of potato produce, thus increased his/her credibility to get the loan. However, as revealed by bank and microfinance officers, they always face challenges in assessing the smallholder farmer's applications due to their obstacles of keeping financial records, which affected on some farmers of not accessing the agricultural loans.

Other conditions required for a farmer to apply for agricultural loans include, loan size (mean statistic =1.9309) , required quota on saving account (mean statistic =1.8036), cultivated farm size (mean statistic =1.327) and fulfilling government conditions (mean statistic =1.069).

Table 4.4: Essential requirements for borrowing from agricultural financing providers

Essential requirements for borrowing	Mean Statistic	Std. Error
Collateral (assets certificates: land or house titles)	3.102	0.099
Member of any registered coop./association	2.702	0.106
Agreement with Spouse	2.553	0.101
Farmer's repayment records	2.324	0.105
Profitability of farm (Farmer's Capacity)	2.178	0.100
Farmer management abilities	1.945	0.108
Loan size	1.931	0.114
Quota amount on Saving account	1.804	0.101
Farm size	1.327	0.104
Government Condition	1.069	0.091
Volume of potato produce in stock to supply	0.800	0.087
Existence of sales contracts.	0.204	0.048

However, considering the category of farmers involved in potato value chain, these conditions were very hard to fulfil. Usually, smallholder farmers lacking the investment for agricultural activities did not use banking systems.

4.3.4 Main uses of agricultural financing in potato farming

Agricultural financing in potato farming offered opportunities for potato farmers to increase funding for potato production efficiency and enhance quality through the utilization of agricultural technologies such as us of high yielding seeds, both organic and inorganic

agrochemicals, and other agricultural equipment required in the production processes. improve efficiency through use agricultural technology including the use of the high yielding seeds, organic and inorganic fertilizers and other agricultural equipment needed in their production processes. Table 4.5 captures the mean statistic of the use of agricultural financing in potato farming. Fertilizers and pesticides application and buying improved seeds occupied the big use of the agricultural loan at mean statistic of 3.505 and 3.400 respectively. The two variables constitute the key elements for the increase of productivity in the area. The use of the loan for hiring farm workers and renting farms was at mean statistic of 1.862 and 1.451 respectively. However, as from the results farmers did not request much for the marketing of their produce. The use of the loan for transporting potato to market and acquiring market information was at mean statistic of 0.154 and 0.091 respectively.

Table 4.5: Main uses of agricultural financing in potato farming

Main uses of credit in potato farming	Mean Statistic	Std. Error
Buying fertilizers and pesticides	3.505	0.072
Buying improved seeds	3.400	0.080
Hiring farm workers	1.862	0.110
Farm rental	1.451	0.108
Buying land	0.669	0.083
Harvesting activities	0.562	0.073
Negotiating potato selling price	0.215	0.051
Debt repayment	0.193	0.045
Buying or Hiring agriculture machineries	0.167	0.039
Transporting potato to market	0.154	0.037
Acquiring potato market information	0.135	0.030

Paying taxes	0.091	0.028
Opening a supermarket	0.025	0.011

4.4 The effects of agricultural value chain financing on potato productivity in Rwanda

The second objective of the study was to determine the effects of agricultural value chain financing to improve productivity in Rwanda. This objective aimed at estimating the changes between use or not use agricultural loans in potato production. The agricultural value chain financing is useful for ensuring that farmers have liquidity to purchase improved seeds, fertilizers, and access technology as well as increased productivity and meet market demands. Table 4.5 demonstrates a positive impact agricultural finance, use of agricultural inputs and improving productivity. The findings implied that the limited investments would constrain the access to improved seeds and fertilizers, efficient workers, and limited land capacities for all non-participants to agricultural financing. However, when examining the effects of agricultural financing on potato productivity, it was prejudiced to assign the differences in crop yields between the two groups solely to the use of agricultural financing and ignore other attributes of farms and farmers characteristics which may also be responsible for the differences in investments used and the productivity.

Therefore, the effect would be estimated through the use of the ATT and ATU. These justified the reasons of using PSM and ESR. The basic idea behind the use of PSM is to match the treated household with untreated household and measure the average difference in the outcome variable between the treated and untreated households.

4.4.1 OLS Regression Results

The goodness of fit test statistic indicate that the Endogenous Switching Regression models fit the data well (χ^2=202; p=0.000). The correlation coefficients (rho) are positive (Table 4.6). The correlation coefficient of the relationship between the decision not to allocate agricultural loan to potato production and quantity of potato harvested equation is statistically significant, suggesting that households that chose not to use credit in financing potato production harvested lower quantities of potato from that decision than a random household from the sampled households would have harvested. At the same time, households that used the agricultural loan in

potato production did not harvest more or less than a random household. The statistically significant correlation coefficient indicates presence of self-selection. Furthermore, the probability ratio test for the selection and outcome equations' joint independence was statistically significant. Thus, Endogenous Switching Regression (ESR) was appropriate model to estimate the three equations simultaneously.

Table 4.6: OLS Estimates of the correlation coefficient of the relationship between participants and non-participants to agricultural loan

	Non- Participants to agricultural loan.		Participants to agricultural loan	
	Coef.	Std. Err.	Coef.	Std. Err.
Sex of HH head (1=Male, 0 otherwise)	-0.089	0.146	0.147	0.095
Age of HH head	0.015	0.009	-0.002	0.006
Education level	0.425***	0.111	0.118	0.089
Farming experience	-0.061	0.061	-0.035	0.037
Household size	-0.002	0.046	0.033	0.029
Farm size under potato	0.625***	0.117	0.577***	0.065
Log household income	0.552***	0.092	0.387***	0.103
Constant	-0.067	1.217	2.436	1.649
Wald χ^2	202.00***			
Rho_1	0.480			
Rho_2	0.901***			
Sigma_1	0.699***			
Sigma_2	1.313***			
LR test	25.95***			

Note: *** denotes significance at 1%

Table 4.7 shows the estimated quantity of potatoes harvested under the observed and counterfactual scenarios of farm household use of agricultural loans in farming. The estimated quantity of potatoes harvested by households that used agricultural credit was approximately 5.150 metric tons. On the other hand, the observed quantities of potato harvested by non-participants to agricultural credit were 1.658 metric tons. This could imply that households that allocated credit to potato production produced approximately 211 % (about 3.492 metric tons) more potato output than households that did not allocate credit to potato production. However, this interpretation does not reflect the true treatment effect of agricultural credit. Instead, the ATE should be used to provide a more accurate interpretation of the results.

The counterfactual situation shows that households that allocated credit to potato production would have harvested 4.610 metric tons of potato if they had not allocated the credit to potato. In other terms, participants to credit on potato production would have harvested approximately 11.71 % (0.540 metric ton) less of potato if they had allocated credit to potato production activities. In contrast, household that did not allocate credit to potato production would have harvested 445% (9.027 metric tons) more of potato if would have used credit. Thus, it implies that they would have harvested 7.370 metric tons more for having used credit on potato production.

Table 4.7: ESR estimates of use of agricultural credit treatment effects

	Used	Not used	ATE
Participants to Credit (ATT)	5149.676	4609.945	539.731 (70.610)***
Non- Participants to credit (ATU)	9027.255	1657.524	7369.731 (1679.897)***
Heterogeneous effects	-3877.579	2952.421	-6830

Note: *** denotes significance at 1%

Furthermore, Table 4.7 provides base and transitional heterogeneities that account for selection bias (heterogeneity effects). The transitional heterogeneity is negative (-6830), which implies that the treatment effect of loan use is significantly smaller for loan using households than for those who did not allocate the credit to potato production. Nonetheless, participants to credit were better off allocating credit to potato production than not using it produce the crop.

This finding suggests potential heterogeneity in decisions regarding the decision to allocate or not to allocate credit to potato production.

Propensity Score Matching (PSM)

Becker and Ichino (2002) explain that two crucial econometric assumptions have to be met to ensure the results obtained from PSM estimators are reliable. The first assumption is the overlap assumption, which is also referred to as common support. This assumption holds that treatment and control observations have to be comparable in the propensity score distribution. The results in Table 4.8 shows sufficient overlap after matching 579 observations treated and non-treated observation. Additionally, the plots in Figure 4.5 indicates that not too much probability mass that is either nearly one or zero using the nearest neighbour estimator. For the Kernel estimator, Figure 4.6 also shows no mass distribution of the conditional densities that tend to be either zero or one for each level; that is observed that the predicted probabilities are neither close to zero or one. These results indicate that the overlap assumption was met by the two estimators. In other words, the predicted probabilities that a non-agricultural credit participant is a non-participant and the predicted probability that agricultural credit participant is a non-agricultural credit non-participant have their respective mass overlapping each other.

Table 4.8: Description of the estimated propensity score in region of common support

	%iles	Smallest		
1%	0.160	0.131		
5%	0.208	0.137		
10%	0.259	0.138	Obs.	579
25%	0.345	0.145	Sum of Wgt.	579
50%	0.465		Mean	0.474
		Largest	Std. Dev.	0.169
75%	0.591	0.861		
90%	0.721	0.869	Variance	0.029
95%	0.775	0.874	Skewness	0.254
99%	0.854	0.878	Kurtosis	2.383

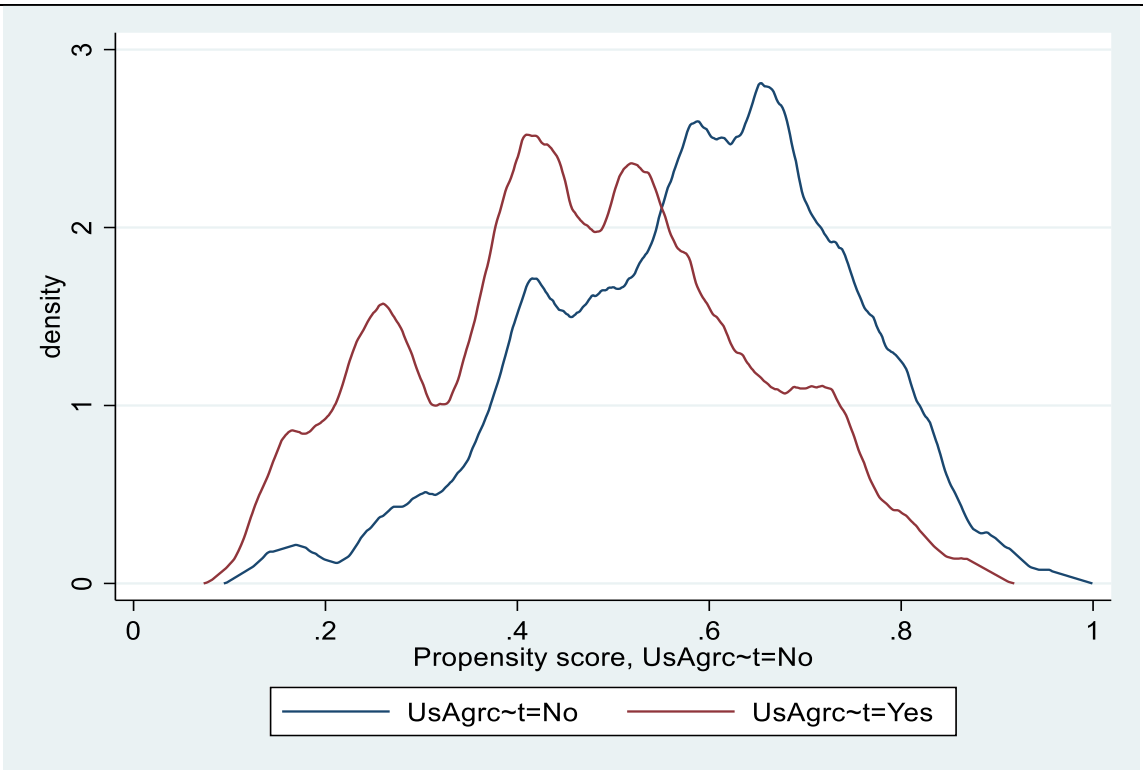

Figure 4.5: Distribution of predicted probabilities for testing overlap assumption of the nearest neighbour assumption

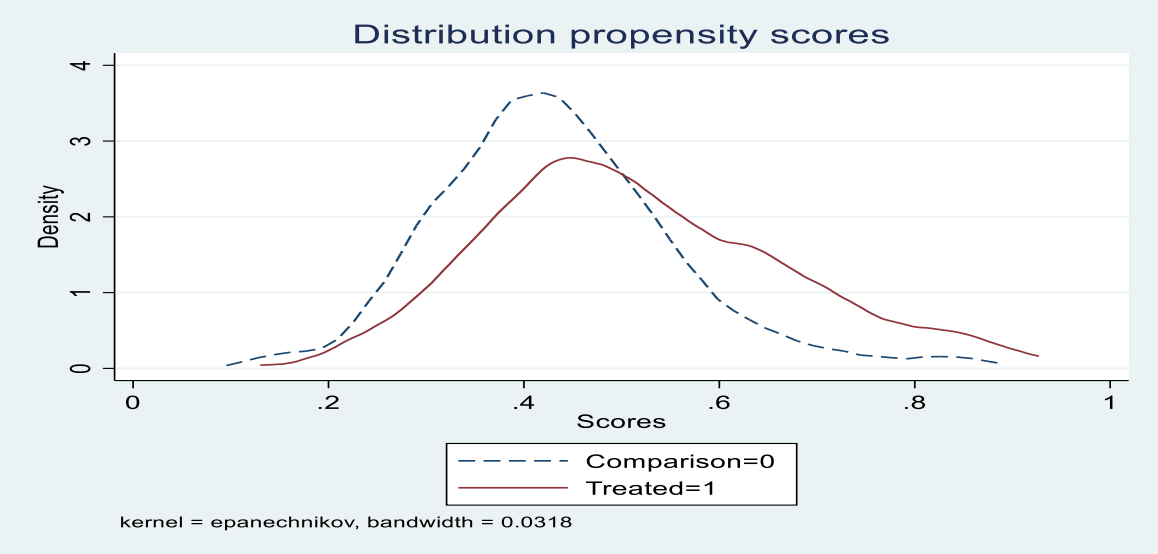

Figure 4.6: Distribution of propensity scores under the Kernel estimator

Furthermore, the balancing property of PSM has to be achieved for the overlap assumption to remain valid. Table 4.9 depicts the number of treated and control observations on the common support. In total, the nearest neighbour algorithm eliminated 156 observations that are not within the common support region to ensure that the estimator meets the overlap condition. On the other hand, 275 treated and 304 control observations are matched using kernel matching method. PSM satisfies the overlap condition by deleting observations with smaller and larger propensity scores in each category of individuals. Therefore, overlap assumption is satisfied.

Table 4.9: Common support condition by matching algorithm

	Nearest Neighbour			Kernel		
Treatment assignment	Off-support	On-support	Total	Off-support	On-support	Total
Non-participants	156	148	304	-	304	304
Participants	-	275	275	-	275	275
Total	156	423	579		579	579

Choice of Matching Method and Test for Covariate Balancing

There exists trade-off in the calculation of the ATT, whose magnitude may differ depending on matching algorithm used. However, asymptomatically, matching algorithms should produce similar results, which, in practice, may not be the case because of differences in their efficiency and bias involved (Caliendo & Kopeinig, 2008). Although there are several matching algorithms, the study used kernel and *k*-nearest neighbour matching estimators. Kernel is selected because of its bandwidths perform well in terms of bias and mean squared errors reduction (Galdo *et al.*, 2008). Kernel matching estimators also provide alternative way of calculating standard errors compared to other nonparametric matching algorithms. On the other hand, *k*-nearest neighbour matching methods imposes a maximum difference in predicted probability scores between the control and treated observations within a matched pair, resulting in less biased treatment effects estimates (Austin, 2011). Furthermore, an optimal nearest neighbour matching tends to provide estimates with greater precision because of smaller variation in estimated treatment effects.

Figure 4.7 depicts a pictorial representation of the density allocation of the propensity scores of treated and untreated individuals. The upper half of Figure 4.6 depicts the allocation of propensity scores of farm household participants of agricultural credit, while the bottom half display the allocation of propensity scores for farm households that did not use the agricultural credit on potato production. There is a high level of common support because none of the households in either treatment or control groups fall off region of common support. This indicates the quality of the matches by the estimators.

The balancing of covariates ensures that the variables included in the estimators are as comparable as possible between two matched groups. In other words, the averages of all covariates should not statistically differ between participants (treated) and non-participants (control) of agricultural credit. However, the balancing of covariates may differ depending on the type of matching method employed. Despite producing almost similar qualitative results, quantitative findings may slightly differ between Kernel and Nearest neighbour matching techniques. Therefore, balancing of covariates is crucial in understanding whether the differences in independent variables used to predict the propensity scores have been eliminated by the two estimators.

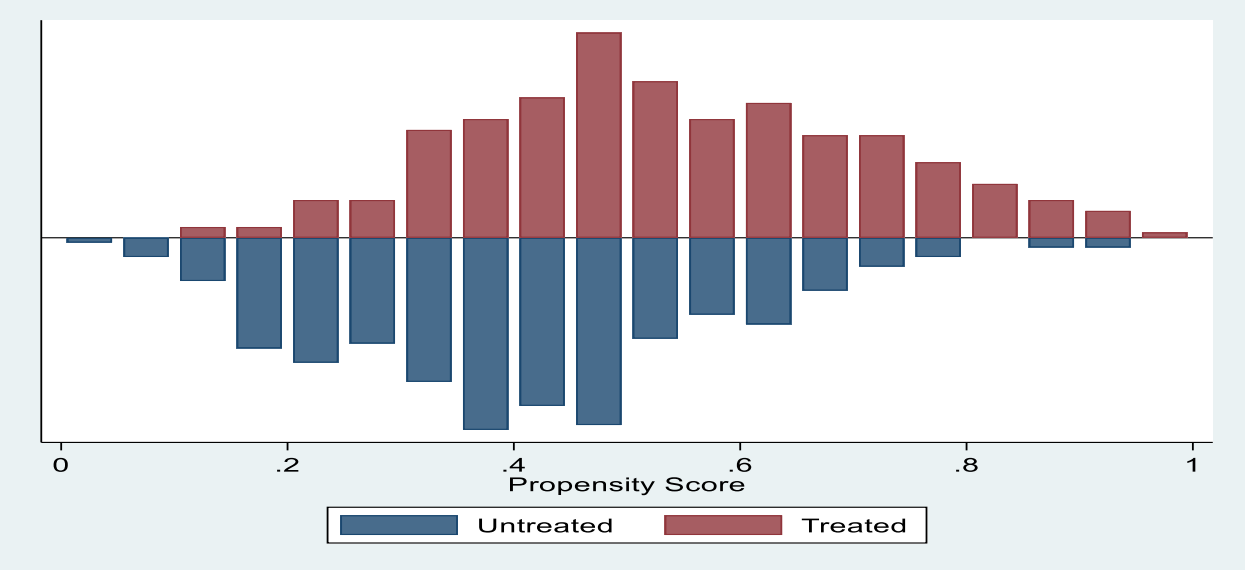

Figure 4.7: Distributions of treated and control households in the region of common support

Table 4.10 displays the mean differences as a quality control measures for the matching process. The table also shows the quality of the matches both before and after matching, which can be used to determine whether the balance of covariates condition was met.

Some conditions must be met for covariates to be considered balanced between the treated and control households. The means of the covariates must not be statistically different at 5 % significance level. However, the findings in Table 4.10 shows that all covariates included in the nearest neighbour and kernel estimators did not significantly differ between household that allocated credit to potato production and that who did not. Therefore, a better balance was achieved for all covariates for treated and non-treated households.

Table 4.10: Test of the means differences between treated and non-treated household before and after matching disaggregated by type of matching algorithm

		Kernel					Nearest neighbour (3)				
		Users	Non-users	% bias	% bias red.	P	Users	Non-users	% bias	% bias red.	P
Sex of HH	Unmatched	0.582	0.647	-14		0.105	0.582	0.647	-13.5		0.105
head	Matched	0.585	0.594	-2	84.9	0.815	0.585	0.591	-1.3	90.6	0.885
Age of HH	Unmatched	41.705	41.298	4.6		0.576	41.705	41.298	4.6		0.576
head	Matched	41.750	41.686	0.7	84.4	0.933	41.750	41.223	6	-29.2	0.489
Education of	Unmatched	1.338	1.071	41.4		0.000	1.338	1.071	41.4		0.000
HH head	Matched	1.331	1.350	-2.9	93	0.735	1.331	1.370	-6.1	85.3	0.474
Marital											
status	Unmatched	0.855	0.900	-14		0.096	0.855	0.900	-13.8		0.096
	Matched	0.860	0.859	0.5	96.3	0.956	0.860	0.862	-0.4	97.3	0.967
Farming	Unmatched	2.844	2.916	-5.4		0.512	2.844	2.916	-5.4		0.512
experience	Matched	2.846	2.907	-4.6	14.8	0.595	2.846	2.804	3.1	42.3	0.720
Household	Unmatched	5.051	4.893	10.5		0.204	5.051	4.893	10.5		0.204
size	Matched	5.059	5.060	-0.1	99.2	0.992	5.059	5.012	3.1	70.5	0.720
Farm size	Unmatched	0.676	0.405	35		0.000	0.676	0.405	35		0.000
	Matched	0.658	0.643	2	94.3	0.830	0.658	0.652	0.8	97.7	0.932
Housing	Unmatched	0.982	0.951	16.9		0.044	0.982	0.951	16.9		0.044

assets	Matched	0.982	0.977	2.3	86.4	0.735	0.982	0.988	-3.4	79.8	0.562
Livestock	Unmatched	0.458	0.317	29.2		0.000	0.458	0.317	29.2		0.000
assets	Matched	0.456	0.433	4.7	83.9	0.594	0.456	0.403	10.9	62.6	0.215
Training	Unmatched	0.455	0.317	28.5		0.001	0.455	0.317	28.5		0.001
in potato	Matched	0.452	0.474	-4.6	83.9	0.606	0.452	0.478	-5.3	81.3	0.548

Another criterion for determining balancing of covariates requires that the mean bias should be less than or equal to 5 %. The mean bias for all covariates after matching using kernel algorithms are less than the standard 5 % (Table 4.10). However, except for sex of household head, marital status, farming experience, household size, farm size, housing assets, the mean bias for the other covariates are larger than the standard 5 % for nearest neighbour (Table 4.10).

Nonetheless, the mean bias for all covariates used kernel matching is 2.4 after matching, while that for the nearest neighbour is 4 (Table 4.11). Therefore, both estimators met the balancing of covariates condition after matching. Furthermore, the absolute standardized difference in means of propensity score of matched treated and control observations, also referred to as Rubin's B, is also used to validate the balancing of the covariates. The standard validation procedure requires that the Rubin's B estimate should be less than 25 % for the covariates to be considered balanced. The estimated Rubin's B values for kernel and nearest neighbour matching algorithms after matching are 10.6 % and 15.9 % respectively (Table 4.11). Thus, the two matching methods sufficiently balanced the covariates and improved the quality of the matches.

Table 4.11: Rubin's B values for Kernel and nearest neighbour matching algorithms after matching

Kernel

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	Med. Bias	B	R	% Var
Unmatched	0.091	73.77	0.000	19.9	15.3	73.5*	1.13	20
Matched	0.002	1.54	0.999	2.4	2.2	10.6	1.41	0

* if B>25% , R outside [0.5; 2]

Nearest Neighbour (3)

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	Med. Bias	B	R	% Var
Unmatched	0.091	73.77	0.000	19.9	15.3	73.5*	1.13	20
Matched	0.005	3.42	0.970	4.0	3.3	15.9	1.07	0

* if B>25% , R outside [0.5; 2]

Sensitivity Analysis

PSM has to satisfy the conditional independence assumption (CIA). The assumption states that the effects of participation are not influenced by the correlation between selection decision and unobserved factors (Imbens, 2004) In other words, the decision to use agricultural credit on potato production is entirely influenced by covariates. The implication is that the effects of agricultural credit are not affected by hidden bias. In other words, the study made effort to minimize the obscured bias that the interpretation of the causality by running Rosenbaum bounds test of the sensitivity of the treatment effect to hidden bias. The importance of the Rosenbaum bounds test is that effects estimators are not robust to unobserved heterogeneity. As such, the test helped to verify whether the effect of allocation of credit to agricultural production was altered by the existence of obscured bias which affects both the probability of allocating credit and the quantity of potato harvested. The Rosenbaum bounds tests the hypothesis that there is no treatment effect. In other words, the impact of allocating credit to potato production results from confounding factors, which are the unobserved variables.

Table 4.12 reports the Rosenbaum bounds (rebounds) results. For the purpose of interpreting estimates in Table 4.12, the upper bound test statistic is reported as Q+. Besides, the Rosenbaum upper bounds test statistics are for different gamma values and statistically significant at 1% level. This indicates that the null hypothesis that the treatment effect for participation has been overestimated is rejected. Instead, the volume of potato harvested is due to the allocation of credit to potato production but not as a result of unobserved factors. The hypothesized effect direction of this study was that the use of agricultural credit on potato farming would not positively affect the quantities of potato harvested. The study found that at 5 % level significance level, the hypothesis is toughly rejected. For instance, the first five gammas are statistically significant at 1 % level. This result implies that the treatment effects are not affected by the hidden bias. In other words, the impact of agricultural credit on harvested quantities of potato is not influenced by unobserved covariates, but by household decision to allocate credit allocation to potato production. The selection of the best matching algorithms allowed estimation of average treatment effects.

Table 4.12: Sensitivity Analysis

	Kernel				Nearest neighbour (3)			
Gamma	sig+	sig-	t-hat+	t-hat-	sig+	sig-	t-hat+	t-hat-
1	0	0	0.731	0.731	0	0	0.684	0.684
2	0.000	0	0.495	0.964	0.000	0	0.397	0.971
3	0.000	0	0.357	1.093	0.001	0	0.235	1.132
4	0.000	0	0.259	1.179	0.044	0	0.120	1.246
5	0.006	0	0.186	1.246	0.289	0	0.040	1.326
6	0.045	0	0.126	1.299	0.648	0	-0.027	1.392
7	0.152	0	0.076	1.341	0.880	0	-0.085	1.445
8	0.327	0	0.033	1.377	0.969	0	-0.133	1.490
9	0.524	0	-0.003	1.408	0.994	0	-0.173	1.532
10	0.696	0	-0.037	1.435	0.999	0	-0.209	1.567

Table 4.13 presents Kernel matching and Nearest Neighbour algorithms' effects of use of agricultural credit on quantity of potato harvested. The outcome is measured in tonnes. Fifty bootstraps were run to test the significance of the treatment effects. The results showed that the average treatment effect on the treated for results obtained from kernel matching algorithm was 2.48 tonnes. The difference was highly significant ($p < 0.001$). Treatment effect estimates from nearest neighbour algorithm indicated a highly statistically significant difference of 2.42 tonnes. The results obtained from the two matching methods showed that use of agricultural credit had a positive significant effect on the quantity of potato harvested. In other words, the farm households who allocated credit to potato production harvested significantly higher volumes than those who did not invest in potato production. Access to and use of agricultural credit has offered opportunities to potato farmers to easily use high yield seeds, use organic and inorganic fertilizers, use of pesticide and have access to other agricultural inputs necessary to increase and improve productivity in the study areas.

Table 4.13: Propensity score matching estimates of the effects of use of agricultural credit on the quantity of potato harvested

	Sample size		Mean outcomes				
Matching Algorithm	Users	Non-users	Users	Non-users	ATT	Std. Error	t-stat
Kernel	272	309	4.881	2.397	2.484	1.10	7.00***
Nearest Neighbour	272	309	4.881	2.465	2.416	1.11	6.53***

The positive impact of agricultural credit is in line with results reported by earlier studies in Sub-Saharan Africa and other developing countries. For instance, Awotide *et al.* (2015) found that farmers who obtained credit increased cassava productivity than random farmers in Nigeria. In another study in Rwanda, Ali *et al.* (2014) discovered the evidence that farmer who had unconstrained access to agricultural loans recorded seventy percent higher productivity than those of credit constrained. Furthermore, aggregated findings as reported by Saleem and Jan (2011) indicated that credit in multiple forms and from different formal sources increased agricultural production in Pakistan. For example, seed, fertilizer, pesticide, irrigation, and mechanization credit strongly increased agricultural gross domestic product, with impact effect of above eighty percent. Other previous studies that found positive impact of credit in agricultural productivity are Rahman *et al.* (2014) in Pakistan and Agunuwa *et al.* (2015) in Nigeria.

4.4.2 Constraints faced by smallholder farmers to access to agricultural financing for potato production

Agricultural financing and much investment in potato production is an innovative approach that helps farmers to increase production, improve efficiency and respond to consumer demands. The approach offers opportunities for potato farmers to expand financing for potato productivity and improve efficiency through use agricultural technology including the use of the high yielding seeds, organic and inorganic fertilizers and other agricultural equipment needed in their production processes.

However, small potato producers remain victims of various constraints to access to and use of agricultural financing approach to increase production. In Figure 9 the means for pooled sample were considered to sort out the critical constraints that limit farmers from accessing to agricultural financing.

Afraid to borrow,

Both participants and non-participants were afraid to borrow. Participants in the agricultural loans were more afraid than non-participants. The farmers show that they are not confident in accessing agricultural loans provided by different financial providers particularly Banks. The fear of borrowing arose from little experience of using loans in the production of potatoes.

Interest rates and other loan charges are too high for an agricultural loan,

High interest rates charged by financial providers made accessing to agricultural loans risky for the farmers. From this study, it has been realized that Microfinance institutions charge the interest rate ranging between is 20 and 30 % while commercial banks charge interest rate ranging between 15-20 %. High interest rates disappointed smallholder farmers from use of loans in the production of potatoes.

Unpredictable production,

The production of potato requires much investment in improved seeds, use of fertilizers and weather conditions. Smallholder farmers hesitated of good production primarily due the lack of improved seeds and shortage of fertilizers which lead to low production. Farmers also reported that their potato plots were subjected to weather and climatic risks. The uncontrolled natural disasters, droughts and floods, disturbed their production plan. Failure to estimate the exact quantity of potato to harvest was considered as wastage of resource and constituted barrier to participate to agricultural financing.

Short repayment period for the loan provided for agriculture,

Farmers are bound to pay their loans on due time. However, they have been complaining about the short time granted to repay their loans and penalties charged for not paying on time. Potato growers have been requesting longer grace period between planting, harvesting and marketing their produce and time to repay their loans. Unfortunately, financial providers were more concerned about rigorous loan recovery which discouraged farmers from easily applying for loans to increase their productivity.

Uncertainty of repayment,

Though agricultural loans are important in potato production, farmers have revealed their uncertainty of repaying their loans on time. This uncertainty was based on production constraints including inadequate improved seeds, low access to fertilizers, weather and climate changes and market price volatility. Due to all those challenges, farmers declared their incapacities to repay the loans on time or meet other bank requirements.

Inadequate collaterals,

Farmers have difficulties in guaranteeing their loans. The financial providers' attitude is fully centred on tangible collaterals, land and houses of high values to recover the loans. However, the fear of farmers to engage the family properties to secure loans worsened their access to agricultural financing. Moreover, farmers' saving attitudes constituted another limitation to farmers to access of agriculture financing.

Financial illiteracy and inadequate knowledge and skills in project budgeting,

The little education, little knowledge on how modern lending institution work. Farmers have demonstrated their problems of understanding some of the terms used by banks while filling up the loan application. Famers have also expressed lacks of knowledge and skills in project planning and budgeting, poor quantification of cost and earning for his / her project the constituted one of the limiting factors for financial providers to allocate loans to potato smallholder farmers. The study found other constraints faced by smallholder farmers to access to and use of agricultural loans such as inadequate savings within lending institutions, inadequate information on availability of loans for agriculture, long application procedures for cultivation loan compared to other loan, many documents to process the agricultural loan and relatively low loan provided that could not cover the farmers' needs constituted other threats for potato farmers to use agricultural financing in their production activities.

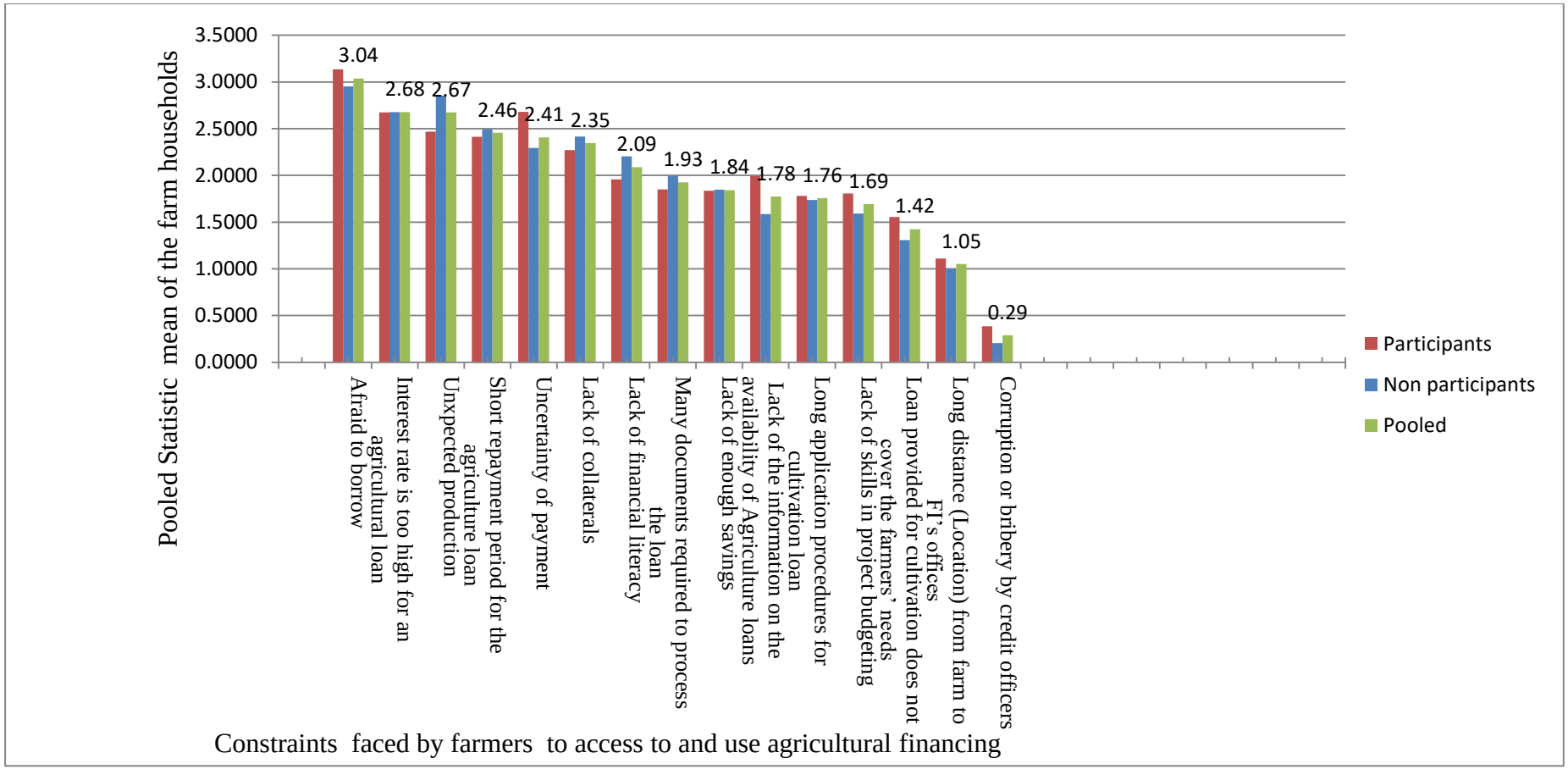

Figure 4.8: Constraints faced by smallholder farmers to access to agricultural financing for potato production

As presented in figure 4.9, farmers have proposed different measures that would help them to overcome the constraints faced by smallholder potato farmers to access and use agricultural financing. 65.1 % of the farm households suggested for lowering the interest rate, 61.71 % suggested to have three to six months grace period for agricultural loans, 60 % suggested that farmers be trained on the needs of loans for agricultural production prior to using them, 40.17 % suggested to have insurance scheme that secure their agricultural practices, 37.26 % suggested to have financial products that adequately match the farmers needs while 15.04 % suggested to set up financial agencies near to framers' locations.

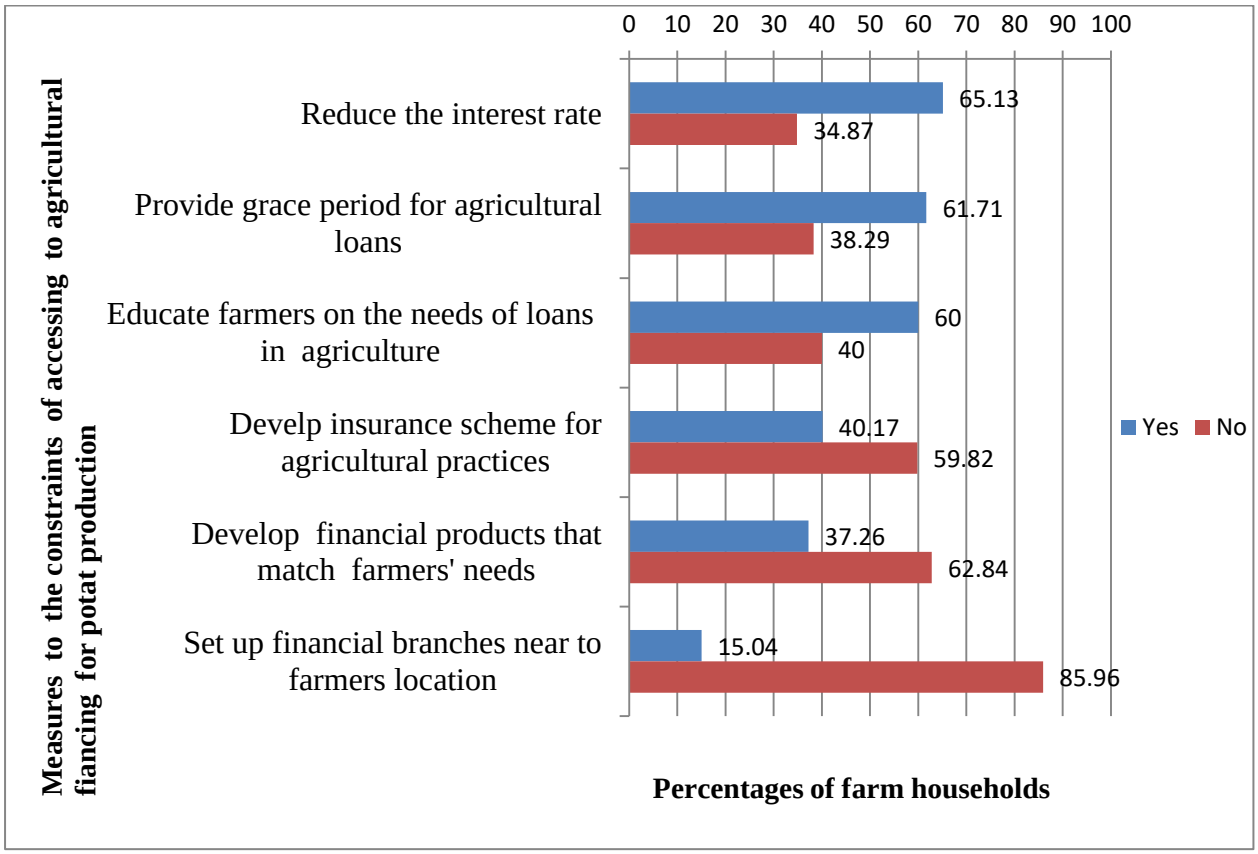

Figure 4.9: Measures to overcome constraints faced by smallholder farmers to access to and use of agricultural financing for potato production

4.5 Determining the factors influencing smallholder farmers' access to potato to markets

4.5.1 Appropriateness of the DHM

The Wald Chi-square statistic (χ^2 = 67.71) and its associated p-value, are statistically significant at 1 % level ($p < 0.001$), meaning the double hurdle model (DHM) fit the data well. However, it was crucial to disentangle appropriateness of the double hurdle model to the standard Tobit model. The test value is greater than the tabulated Z values, confirming that the double hurdle model performs better than the standard Tobit model in estimating determinants of farm household's market access or participation.

4.5.2 Results from DHM

The descriptive statistics of the variables used in the DHM have been discussed in previous sections. This subsection discusses only the double hurdle model results of factors influencing potato farmers' access to market. Table 4.14 illustrates the factors influencing the smallholder farm household's market access or participation decision and extent of farmers' market participation.

Table 4.14: Estimates of DHM for farm households' market access/participation

	Market participation			**Extent of participation**		
	Coef.	Std. Error	dydx	Coef.	Std. Error	dydx
Age of HH head	0.001	0.011	0.000	-0.004	0.005	-0.004
Sex of HH head	0.429**	0.177	0.071	0.264***	0.073	0.264
Marital status	0.077	0.238	0.018	0.002	0.111	0.002
Education	0.090	0.141	0.034	0.088	0.056	0.088
Household size	0.061	0.059	0.005	0.027	0.024	0.027
Farming experience	0.065	0.075	0.014	0.006	0.030	0.006
Household income	0.022	0.094	-0.001			
Membership to farming organizations	2.786***	0.361	0.406			
Distance to market	-0.005	0.006	-0.001			
Farm size				0.629***	0.046	0.629
Price				0.001**	0.011	0.001

Transport assets			0.193	0.140	0.193
Time			-0.002	0.006	-0.002
Agricultural credit			0.685***	0.072	0.685
Constant	-1.169	1.310	6.767	0.316	

The household head' sex had a positive and significant influence on farmers' decisions to participate in the potato market. The partial effect for sex is 0.071, suggesting that man headed households have 7.1 % higher chances to participate in the market than women headed household. The result could be attributed to male heads holding substantial power in household decision-making processes because they hold vast ownership of productive resources possibly utilized in potato production. Reyes *et al.* (2012) and Sebatta *et al.* (2014) reported similar findings in their studies that focused on market participation and sale of potatoes in Angola, and determinants of smallholder farmers' decision and level of participation in the potato market in Uganda, respectively. They also reported that females are less likely to participate in the process of selling potato and price and other transactional bargaining. However, the findings of this study contradict Mbitsemunda and Karangwa (2017) who found that sex of the household did not have a significant effect on bean market participation of bean growers. Furthermore, market participation was significant and positively related to membership to farming organizations. In other words, farmers who were belonged to potato producer groups (40.6 %) had better chances of participating in the output market than non-group members. This result was not surprising because rural organizations usually facilitate farmers to access to market information and link them to formal markets. Membership to farming organizations also strengthens and increases farmers' access to pooled transportation of potato, and producers' power in price negotiations (Key *et al.*, 2000). The marketing services offered by groups possibly encouraged group members to participate in the potato markets. Egbetokun *et al.* (2017), Ingabire *et al.* (2017), and Ahn *et al.*(2018) reported similar studies among smallholder maize, bean, and rice farmers in Nigeria, Rwanda and Myanmar respectively.

Moreover, the study determined the factors that influence the extent of farmers' participation potato market. The findings of the study revealed that sex of the household head significantly and positively influenced the extent of farmers' market participation. The positive association between sex of the household head and the quantity of potato sold explained differences in gender roles within rural farming households. In Rwanda, women

provide over 60 % of household labour, tending to spend more time on both farm work and non-farm work. But their engagement in the decisions regarding the quantity of produce to be sold to market remains limited compared to males' engagement. In addition, potato is bulky and requires access to sufficient resources for transportation. In Rwanda, the household resources are primarily owned be men, explaining the disparities in extent of market participation between male-headed and female-headed households. This finding underpins previous the findings reported by Marenya *et al.*(2017) and Gebre *et al.*(2021) who reported that gender of household head was an important variable that explained gendered disparities in extent of market participation in Ethiopia.

The findings also showed that farm size significantly and positively influenced the extent of farmers' market participation. Potato farmers having larger land properties are likely to have greater opportunities to produce more and have more potato surplus for sale. These findings reinforce the findings reported by Abayneh and Tefera (2014), Ahn *et al.*(2018), Key *et al.*(2000), Mshenga *et al.*(2018) that land size positively affect the quantity of produce to be sold in the market. The findings also showed that the price significantly and positively influenced the extent of farmers' market participation at 5 % significance level. The positive relationship between the price and the quantity of potato sold to market explained the farmers' decisions to increase the volume of potato to sell when the market price is high. The findings reinforced the results of Olwande and Mathenge (2012) who reported that the high price of maize had significant and positive influence on the quantities sold by farmers in Kenya. Ahn *et al.*(2018) and Sebatta *et al.* (2014) also discovered that the price had significant and positive influence on potato farmers' decisions to participate to market in Uganda and enhanced the farmers' willingness to produce and increase of proportion of rice to sell in Myanmar respectively.

Agricultural credit also influenced positively the extent of the farmers' market participation. Access to agricultural credit was significant at 1 % significance level. The results revealed that the extent of market participation was higher for potato farmers who used agricultural financing than for those who did not use. The results reinforced the study's findings reported by Ahn *et al.* (2018) and Abayneh and Tefera (2014) who showed that access to agricultural credit had positive and significant effect on the extent of participation of smallholder rice farmers in Myanmar and smallholder bean farmers in Ethiopia respectively. The results reinforced the importance of promoting the use agricultural financing for smallholder farmers to access to agricultural inputs, increase productivity and access to outputs markets to increase farm households' income and improve their livelihood.

4.6 Market outlets choice and constraints facing smallholder potato farmers

To promote the smallholder farmers to a high value market, the market outlet choice is the utmost importance in agricultural value chain. This section discusses the study' findings on factors influencing smallholder potato farmers' choice of market outlets and constraints they face to participate/access to markets outlets.

4.6.1 Factors influencing smallholder potato farmers' choice decisions of market outlets

Potato farmers in Musanze and Nyabihu districts have seven alternatives to choose the market outlets to sell their production. These include consumers, retailers, collection centres, cooperatives, brokers, processors and wholesalers. The results from multivariate probit model were used to analyse and discuss the significance of the factors influencing farmers' choice among the seven market outlets.

The Wald Chi square statistic, $\chi^2 = 296.54$, and its corresponding probability value, $p < 0.001$ were both significant at 1% implying that the MPV fit the data well. The correlation likelihood ratio test of the seven market outlets was statistically different from zero ($\chi^2 = 267.765$ and $p < 0.001$). The null hypothesis of independence for the decision choice between market outlets is significant at 1% significant level. This indicates that the univariate probit model for determining factors influencing farmers' choice of market outlets is untrue and would bias the results. Farmers could exploit the opportunities from supplying multiple market outlets in order to maximize profits and minimize costs (Hardesty & Leff, 2010) of selling to particular markets. In other words, the significant likelihood ratio test indicate that multivariate probit (MVP) model was appropriate to determine the factors influencing farmers' choice to sell potatoes to specific market outlets because it exploits the correlation structures (interdependencies) among the seven alternatives of market outlets. As result, the farmers' decision to sell to a particular market outlet has been influenced by the decision of another market outlet.

The correlation coefficients which showed the direction and strength of the relationship between markets outlets were other crucial statistics results from MVP as illustrated in (Table 4.15). The findings demonstrated that the correlation coefficients for broker and wholesaler; collection centre and wholesaler; collection centre, cooperatives, and broker; processors, wholesaler, and broker; retailer and consumer were significant and positive, implying that farmers were more likely to sell to more outlets simultaneously. However, the correlations between consumer with wholesaler, cooperative, and collection centre; together with

wholesaler and retailer; cooperative and retailer; collection centre and retailer were significantly negative and suggesting less likelihood for the producers to sell to the outlets at the same time.

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Table 4.15: Estimated correlation coefficients between seven market outlets

	Consumer	Retailer	Wholesaler	Broker	Cooperative	Collection centre	Processor
Consumer	1						
Retailer	0.509***	1					
Wholesaler	-0.186**	-0.184**	1				
Broker	0.067	-0.015	0.309***	1			
Cooperative	-0.188***	-0.186***	0.018	0.276***	1		
Collection center	-0.316***	-0.175**	0.176**	0.163**	0.336***	1	
Processor	-0.096	-0.035	0.839***	0.464***	-0.032	0.108	1

Note: ** and *** denote significance at 5 % and 1 % levels, respectively

The predicted probabilities of selling to the market outlets and joint probabilities of selling to the seven market outlets are presented in table 4.16. The probabilities for farm households to sell to processors, brokers, wholesalers, retailers and consumers were -15.2 %, -88.4 %, -116.8 %, , -24.9 %, and -82.8 % respectively, while the probabilities to sell to collection centres and cooperatives were 76.1% and 32.3% respectively.

Furthermore, the study found that there is 0.13 % likelihood of smallholder potato farm households would choose to sell to all the seven market outlets, which is significantly lower than 3.7 % likelihood choice of not selling to the seven market outlets simultaneously.

Table 4.16: MVP linear and joint predicted probabilities

	Mean	Std. Dev.
Linear probabilities		
Consumer	-0.828	0.287
Retailer	-0.249	0.289
Wholesaler	-1.168	0.646
Broker	-0.884	0.145
Cooperatives	0.323	0.201
Collection centre	0.761	0.335
Processor	-1.520	0.797
Joint probabilities		
Successes	0.0013	
Failures	0.0370	

As shown in table 4.17 and table 4.18 , the first remarkable multivariate probit outcome demonstrated that none of the covariates included had a significant influenced on farmers' choice to trade with brokers. Brokers, like some other middlemen in agricultural value chains, overwhelm the potato value chain and wield significant power, allowing them to earn large profit margins (Mitchell, 2011). Undoubtedly, the large profit margin obscures the market due to brokers' influence on final consumers prices paid to farmers. Brokers have significantly access to information about the agricultural product prices greater than farmers and other market players. Fortunately, in this study, many farmers had access to market information, and it had increased their chances of not supplying their produce to brokers. As illustrated in Table 4.17, at 5 % level of significance, farming experience significantly

decreased the probabilities of farm households of selling to consumers. The negative association could be attributed to farmer knowledge of alternative and more profitable markets with possibilities of buying in bulk rather than consumers. Consumers/neighbours may stay in the same villages and buy during harvesting seasons when there are little financial benefits of selling within village due to an abundance of supply.

Furthermore, at the 10% level of significance, farming experience significantly increased the likelihood for farmers to sell potatoes to wholesalers. Farmers located far away from collection point were more likely to sell to wholesalers at farm gate. In this regard, wholesalers serve as facilitators rather than barriers to farmers' access to market. These services, combined with wholesalers' aggregation capabilities, may lower transaction costs, making wholesalers more attractive to farmers. This finding reinforced the findings of Monson *et al.*(2008) who reported that experienced farmers are much more likely to assess the wholesaler demands, thereby increasing their likelihood to sell products to them than through middlemen.

However, farmers with a high household income are more likely to sell potatoes to consumers and collection centres. Farmers with higher incomes are more likely to have more resources to deploy production models with more compelling reasons of selling directly to consumers or collection centres that focused on farm produce that meets required quality standards. Another reason could be that farmers with higher income are less likely to be constrained by insufficient/inadequate resources to finance direct sales to consumers (Rapisarda *et al.*, 2015). Because middlemen are less likely to be engaged in high valued markets, much income-endowed producers may be attracted to sell directly to collection centres or consumers.

Table 4.17: Factors influencing smallholder potato farmers' choice decisions of market outlets

	Consumer		Retailer		Wholesaler		Broker	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Age of HH head	0.008	0.009	0.005	0.008	-0.005	0.010	0.001	0.009
Sex of HH head	-0.040	0.140	0.053	0.123	0.048	0.157	0.023	0.141
Marital status	0.008	0.202	-0.051	0.182	0.334	0.240	0.062	0.209
Education	-0.133	0.106	0.247***	0.094	-0.286**	0.119	-0.078	0.108
Household size	-0.019	0.046	0.049	0.039	-0.163***	0.054	-0.023	0.045
Farm size	-0.0376	0.083	-0.073	0.111	0.365***	0.136	-0.063	0.088
Farming experience	-0.137**	0.056	-0.062	0.050	0.115*	0.064	-0.072	0.055
Household income	0.245***	0.080	0.096	0.071	-0.270***	0.093	0.062	0.081
Membership to farming organizations	-0.133	0.148	-0.082	0.131	-0.017	0.165	0.015	0.150
Distance to market	-0.001	0.003	-0.002*	0.003	-0.019	0.030	0.000	0.003
Transport assets	0.425*	0.255	-0.045	0.246	-0.139	0.383	0.065	0.280
Trust	0.070	0.133	0.151	0.117	0.245	0.144	-0.123	0.134
Access to market information	-0.199	0.327	0.824	0.349	0.410	0.432	-0.211	0.330
Agric. Training	0.123	0.142	0.047	0.127	0.004	0.167	0.011	0.146
Extension contacts	-0.044	0.133	0.026	0.117	-0.209	0.150	-0.082	0.135
Constant	-3.559***	1.143	-2.931***	1.043	2.838**	1.335	-1.131	1.170

Table4.17: Factors influencing smallholder potato farmers' choice decisions of market outlets (continuation)

	Cooperative		Collection Centre		Processor	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Age of HH head	-0.002	0.008	-0.002	0.009	0.002	0.011
Sex of HH head	-0.122	0.125	-0.030	0.137	0.069	0.176
Marital status	-0.010	0.185	-0.172	0.212	0.422	0.277
Education	-0.023	0.096	0.005	0.105	-0.265*	0.135
Household size	-0.042	0.039	-0.041	0.043	-0.130**	0.060
Farm size	0.007	0.153	0.073**	0.111	0.047	0.166
Farming experience	0.000	0.051	-0.006	0.056	0.076	0.068
Household income	0.020	0.071	0.350***	0.081	-0.382	0.104
Membership to farming organizations	-0.079	0.132	-0.371**	0.149	-0.001	0.180
Distance to market	-0.001	0.003	0.001	0.003	-0.005*	0.013
Transport assets	0.141	0.255	0.193	0.310	-0.282*	0.269
Trust	0.147	0.118	0.134	0.130	-0.111	0.162
Access to market information	-0.420	0.321	0.419	0.309	0.203	0.435
Agric. Training	0.050	0.130	0.057	0.142	-0.143	0.189
Extension contacts	0.276**	0.119	0.081	0.129	-0.121	0.164
Constant	0.725	1.037	-3.745***	1.161	3.933	1.500
Wald $\chi^2(98)$	296.54***					
Likelihood Ratio $\chi^2(21)$	267.765***					

Note: *, **, and *** denote significance at 10 %, 5%, and 1% levels, respectively

Instead, better farm household income lowered the farm households' likelihood to sell to wholesalers, which could be credited to the resource-endowed by potato producers and strong social networks with consumers. However, the negative correlation between household income and the likelihood of farm households to sell to wholesalers contracted the findings by Abebe *et al.*(2016) who found that Ethiopian famers with better-resource endowed were likely to benefit while trading with wholesalers.

At 1% and 5% significance levels, the study found that farm or land size has positively and significantly influences on the possibility of selecting wholesalers and collection centres as market outlets. It implies that farm households with larger land sized holding are more likely to increase the production and the quantity supplied. According to the study's findings, additional lands for potato farming will most likely results in greater farm households' preference decisions to supply their produce to wholesalers and collection centres over other markets outlets. The findings supported the findings by Kassaw *et al.* (2019) who discovered that farm households with extra land holding produced high quantity of tomatoes and preferred to sell to wholesalers and consumers.

Furthermore, at 5% significance levels, the likelihood of selecting consumers and processors market outlets were positively and negatively associated with ownership of transport assets. It was obviously expected that there would be a positive and significant relationship between the possessing transportation assets and selecting consumers' market outlet. Since potatoes are bulky agricultural commodities, owning transportation assets represents a significant reduction in marketing costs (transaction costs). Farmers benefits from their transportation assets are not only limited to deliver potatoes to markets on time, but it also allows access to more market information, and have frequent physical contacts with their customers and market agents. Crossley *et al.* (2009) also stated that investments in transportation resources strengthen the sales efficiency, and lower transaction costs. On the other hand, the negative relationship between the farm household's likelihood of selling to processors and household ownership of transportation assets could be based on the transportation services provided by processors. However, those services may not be guaranteed because they are neither time-efficient nor convenient as a self-operated transportation service. This finding contradicts the findings of Donkor *et al.* (2018) who discovered that ownership of a motorcycle or a vehicle positively influenced Nigerian farmers' choices of selling cassava straight to processors.

Based on economic theory, the level of education is very important element in the farm household decision making to sell or to not sell to specific market outlets. Higher levels of education would either decrease the likelihood of selling to retailers or increase the likelihood of selling potato to wholesalers and processors. However, this study found an opposite outcome whereby the education of household head has a significant and positive association with choosing retailers outlet at 1 % significance level and negatively and significantly associated with selecting wholesalers and processors market outlets at 5 % and 10 % significance levels, respectively. There is no immediate explanation for these unexpected outcomes. However, the farm household' level of education was conspired to characterise the main the primary farmer's human capabilities of farm household form marking decisions. Because, farm household head with a higher level of education, is anticipated to have greater access to market information. Smallholder potato farmers are unlikely to trade in the market where transactions continue to rise. Farm households devote their limited resources to commercialize their produce through retail market outlets.

When compared to other markets outlets, the distance to market was negatively associated with the likelihood of farm households to sell to retailers and processors In other words, the further the farm households are from the market, the less likely they are to sell to retailers and processors. Potato is a bulky perishable commodity with transaction costs that may have narrowed sales from farm gate or within the production areas than incurring transportation costs and time to deliver to retailers or processors. These findings are consistent with previous findings by Abate *et al.*(2019) Kassaw *et al.*(2019), Melese *et al.*(2018) and Tarekegn *et al.*(2017) who found that farmers' choices for market outlets are significantly influenced by distance to market.

Furthermore, the study's findings discovered a negative association between the household size and the farm household's willingness for selling to wholesalers and processors. In other words, variability in the number of household members has a significant impact in determining farmers' decisions of not to sell to wholesalers and processors. This finding is reasonable because large sized households have an plenty of labour that can be used to transport potatoes to markets. Besides, using household labour to sell potatoes directly to market allows farmers to earn higher prices because they have direct access to market information that they would not have had otherwise relied on wholesalers and processors' information. These findings collaborate with the argument raised by Leroux *et*

al.(2010) that when no buyers collect produce at the farm gate, large-sized household can transport it to nearest market.

Moreover, at a 5% level of significance, membership to in farmer organizations had a negative influenced on the likelihood of selling to a collection centre market outlet. This indicates that the more participate in farming groups the less the farmers are likely to sell to collection centres. The possible explanation is that farming groups allow their members to yield more and deliver for suitable market outlets.

The study also discovered that the number of contacts or interactions cooperatives had with extension officers had a positive and significant impact on the farmers' abilities to sell potato produce. The number of contacts with extension officers have enabled farmers access to market information, which in turn, influenced their market selection strategies and decisions. For instance, could have used extension information to find cooperatives that support production processes or provided production and marketing services. On one hand, this findings are in line with those reported by Dlamini-Mazibuko *et al.* (2019) who found that access to extension services has a significant impact on smallholder vegetable farmers' market outlet selection strategy in Swaziland. However, the findings the findings of Dlamini-Mazibuko *et al.* (2019) who found that extension services reduced the farmers' likelihood of selling vegetables to formal market channels such as cooperatives and supermarkets.

4.6.2 Constraints smallholder potato farmers faced to access the market

To participate to potato market outlets of their choice, smallholder farmers face different constraints. The major marketing constraints identified include the inadequate market information, high transport cost, long distance to markets, lower investment, inappropriate agricultural technology, high post-harvest and storage handling losses, inadequate and effective selling policies, low farmers' power to potato market and low selling price, price fluctuation and Delaying payments.

Insufficient market information

Easy access to market information lowers transaction cost and increases access to market. Farm households interviewed in both districts stated that they lacked access to market information, particularly the information related to prices and quantities of potato demanded by large consumers. They mostly relied on the information provided by wholesalers and brokers. However, the famers requested for financial support and trainings on the use modern

technology like internet for being directly linked with the end markets particularly of big towns and cities.

High transportation cost

The study revealed that high transportation cost was discouraging factor for selling to their produce to markets of their choice. Majority of smallholder farmers interviewed did not have transport; they transport potato by head or by bicycles to supply their produce to nearest market outlets. However, for farmers who benefited agricultural loans and willing to sell to good markets, they hire vehicles (cars) from local traders to transport the produce to markets. Farmers with limited financing revealed that it was very expensive to hire transportation facilities. Therefore, to overcome the perishability of their produce and reduce the transaction costs, farmers preferred to sell to nearest market outlets at relatively lower prices. The findings collaborate with the findings of Ahmed *et al.* (2016), Kyomugisha *et al.* (2018) and Taiy *et al.* (2016) who discovered transportation costs to be among the hindrances for farmers to sell to various market outlets.

Long distance to markets

For a farm household's access the market, the proximity between both the farm homestead gates and the market outlet is critical. As discussed earlier, potatoes are produced in the high lands of the NorthWest volcanic zone with fertile soils and climatic conditions favourable to potato production. Potato farmers operate in remotes areas and far away from the beneficial market outlets of their choices. The study has found that the disparities between farming and market locations being a limitation to farmers' access to market outlets. As a result, the distance between the farm gates to markets implies additional costs for farm households. These include costs of information, contract negotiation, and contract of execution costs with some other market players. The study remarked that higher transaction costs associated with the longer distance to market outlets discouraged farmers and forcing them to sell at lower farm gate prices resulting to lower commercialization and lower earnings. The long distance to market resulted from inappropriate roads which influenced the increase of transportation costs (Bernard & Spielman, 2009). The findings showed that smallholder farmers' access to potato market remains limited for farmers who did not obtained loans with regards to the quantities sold to various market outlets. The finding backs up the Mshenga *et al.* (2018)'s arguments that the greater the distance between a farmer's premises and the

market place, the more difficult and costly it is to access the market. Therefore, the long distance to markets left farmers into difficulties in accessing to market, increased the transaction costs and reduced the expected returns from their operations.

Lower investment

Though farmers are highly motivated to become prosperous farmers, but their investments are limited for succeeding in potato value chain. Linkage between farmers and prosperous market requires many investments including costs for searching for market information, negotiation and coordination of the market. The study's findings showed that the lower money invested in market information were limiting factor for potato famers'access to market. Farmers declared not having many capacities to invest in marketing system. The public sector should provide legal, political and economic polies that enable private sector to expand and revitalize the financial system, to enable farmers to timely access to short term loans to improve productivity and create market linkages for potato produce.

Inappropriate agricultural technology

Agricultural technology is prime factor to increase farm productivity, increase farmers' income, lower the price of food and improve the farmers' livelihood. The low utilization of improved seeds and fertilizers reduced the quality and the quantity of potato supplied by the farmers who did not use agricultural loans compared to what farmers who used agricultural loans have supplied to market. The finding corroborates with the study' findings reported by Mpandeli and Maponya (2014) that smallholder farmers' inadequate access to appropriate agricultural technologies reduced the productivity and negatively affect the abilities of smallholder farmers' abilities to access to markets locally, nationally and globally.

High post-harvest handling and storage losses

The study discovered that using hoes, picks and other traditional tools damage the potato production. In addition to poor harvest and post-harvest practices, potato farmers lose their produce due to inappropriate storage and packaging facilities. These resulted to poor quality produce supplied to market outlets and low revenue to smallholder farmers. To minimize these losses cold storage and 50 kg packaging sacs would adequately be adopted though farmers declared their financial incapability.

Inadequate and effective selling policies

Inadequate selling polies are one of most constraints to potato marketing in the study areas. Potato marketing system in Rwanda is poorly coordinated. Farmers sell to consumers, collection centres, traders, middlemen and processors without appropriate legal and regulatory frameworks for potato production and potato marketing.

Low farmers' power to control potato market

The study discovered that smallholder farmers have low powers to control the market. Due to inappropriate legal and regulatory frameworks, the market is much dominated by much endowed middlemen and traders who dictate the price to farmers. The inefficient control over market pushed some farmers to leave their production in field or sell it at a price dictated by brokers or wholesalers.

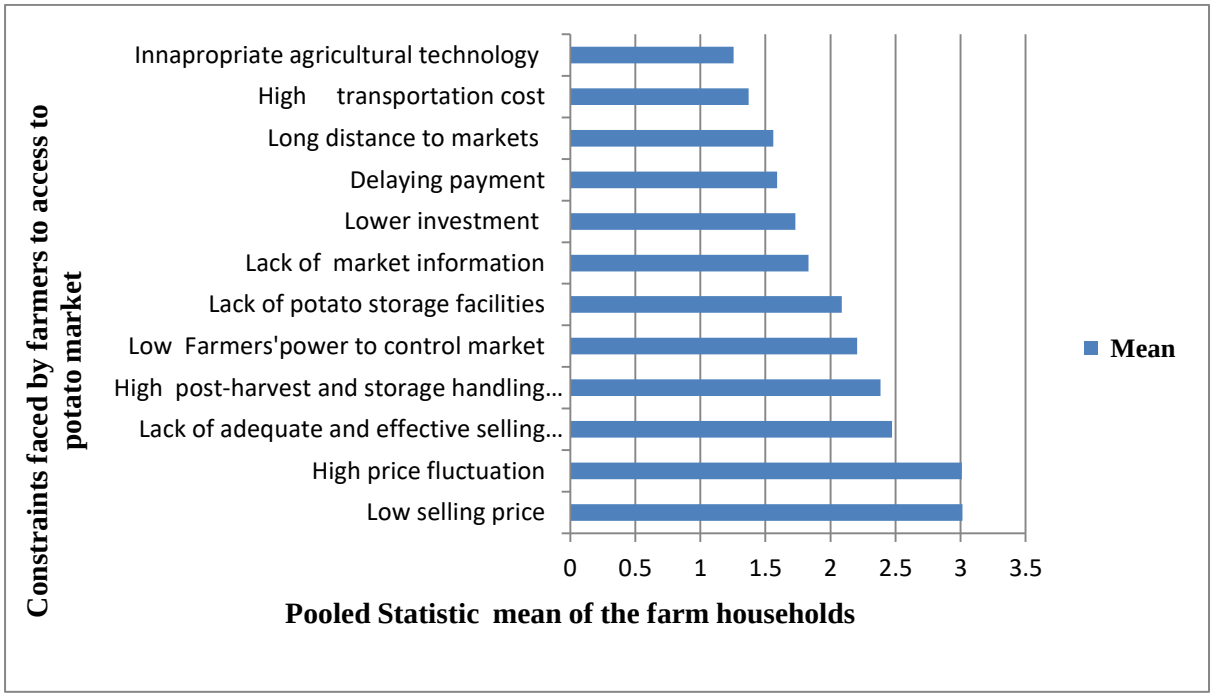

Figure 4.10: Constraints faced by farmers to access to potato market

Low selling price and price fluctuation

The price obtained by farmers for the potato is not constant. Its variability leaves the farmers into suspense of losing interest in growing the crop. As stated by one of interviewed farmer, the unfair prices and its fluctuation pushed them to think of doing other businesses that spending their fortune in unbeneficial crop. For example, during the period data were

being collected (2019), the average price paid to a farmer for Kinigi variety varied between 250-300 Frw/kg, average price paid by final consumer varied between 300-400 Frw. Currently (2020), the average price paid to a farmer varies between 180-200 Frw/kg while the average price paid by final consumer varies between 250-260 Frw. At the harvest period, a farmer cannot predict the market price he/she will receive until the produce reaches the intended market outlet.

Delaying payment

The study also found that farmers have faced a risk of not being paid on time. Due to inappropriate legal and regulatory frameworks, sometimes traders don't pay on spot and farmers wait for days to receive money. Due to financial needs, farmers ended up directly selling after harvest and receive relatively low sale price for their produce.

4.7 Evaluate the effects of agricultural financing on the livelihood of smallholder potato farm households

As indicated in figure 4.2, smallholder farmers finance their potato activities through formal, semi-formal and informal financial services. The findings indicated farm households' likelihood to of increasing productivity and participating in the potato markets had a positive and significant effect. Therefore, after identifying the factors influencing use of agricultural financing on potato productivity and participation in potato market, it is also imperative to assess the effects of agricultural financing on the livelihood of the farm households. The differences in gross margins between 275 participants with 310 non-participants in the use of agricultural financing was also estimated using propensity score matching (PSM). Through the use of psmatch2 command in Stata 16, the effects of agricultural value chain financing on smallholder potato farmers' gross margins were estimated using the average treatment effects (ATT). Kennel matching, and Nearest Neighbour matching were used for computing the estimates (Table 4.19).

Table 4.19: Estimates of average treatment effect (ATT) for the smallholder potato farmers' gross margins (Rwandan francs)

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
	Unmatched	890732.559	367929.68	522802.878	62343.6853	8.39
Kennel matching	ATT	885273.638	511774.586	**373499.052**	70172.9053	5.32**
Nearest Neighbour matching	ATT	885273.638	514942.878	**370330.76**	76679.112	4.83**

** indicate statistical significance at 5 % level of significance

At the time of this study the 1 USD= 895 Frw

As results from Kennel matching, the ATT is equivalent to 373,499 Rwandan Francs (USD 417). This meant that the farmers who participated to agricultural financing have increased their gross margins by 373,499 Rwandan Francs (USD 417) higher than those who did not. The t-statistics for ATT equals to 5.32 at 5 % significance level. According to the Nearest Neighbour matching, the ATT is equivalent to 370,331 Rwandan francs (USD 414). This implies that farmers who participated in agricultural financing have increased their gross margins by 370,331 Rwandan francs relative to those who did not. At 5 % significance level, the t-statistics for ATT equals to 4.83. According to the findings, access to and use of agricultural financing is associated with the increase of farm gross margins.

Furthermore, 93.5 % of the farm households that used agricultural loans in potato production have affirmed having improved their wellbeing while 6.5 % declared no effect on their livelihood. Moreover, the income threshold for farm household participants in the use of agricultural financing has gradually increased This meant that using of agricultural loans for potato production had a positive and significant impact on farm household annual income (Table 4.20), thus improving the household members' livelihoods (Table 4.21).

Table 4.20: Effects of accessing to and using agricultural loan on farm households' income (n=275)

Income of farm household per year	Before accessing and using agricultural loan (RWF)		After accessing and using agricultural loan (RWF)	
	Frequency	%	Frequency	%
< 100000	26	9.5	12	4.4
100001-200000	37	13.5	11	4.0
200001-300000	31	11.3	21	7.6
300001-400000	30	10.9	38	13.8
400001-500000	32	11.6	25	9.1
500001-1000000	44	16.0	67	24.4
> 1000000	75	27.3	101	36.7

Table 4.20 showed that the number of households with low income (less than 100000, 100001-200000 and 200001-300000 RWF) have decreased while the numbers of households with high income (300001-400000, 400001-500000, 500001-1000000 and above) have considerably increased. Moreover, based on the indicators in Table 4.21, the study found that the wellbeing of farm households' members improved through the increased abilities to feed their families, abilities to pay health care fees and abilities to pay school fees at mean statistic of 3.8521, 3.6809 and 3.1914 respectively.

Table 4.21: Indicators of effects of agricultural financing on farm households' livelihood (n=275)

Farm households' livelihood indicators	Mean	
	Statistic	Std. Error
Increase the abilities to feed the family	3.8521	.02767
Increase the abilities to pay health care fees	3.6809	.05257
Increase the abilities to pay school fees,	3.1914	.08056
Access to telecommunications and Media devices (Radio, TV, Mobile phone...)	2.8132	.07050
Improve the physical appearance of my family (clothing, clear skin)	2.6226	.08894
Provide employment to other people around	2.6157	.08522
Access to water and Electricity at home	2.5720	.07864
Spending time with friends and family (recreation)	2.4008	.07775
Building modern/new house (specify the materials)	2.3852	.08055
Buying livestock (cow, sheep, goat, pig)	2.2734	.09578
Buying or extending the land	2.2500	.09635
Being among opinion leaders for decisions making committees (At village level, cell level, sector level, district…)	2.0350	.07823
Buying new household furniture (Sofa, fridge…)	1.5253	.09160
Buying transport assets (a bike or motorbike or car…(specify)	1.1751	.09841

Use of agricultural financing has also enabled the smallholder farmers to access to telecommunication and media devices (mean statistic = 2.8132), improving their physical appearance (mean statistic= 2.6226), proving employment to the surrounding communities (mean statistic= 2.61587), accessing to water and electricity services (mean statistic= 2.5720), spending good time with friends and family (recreation) (mean statistic= 2.4008),

building modern houses (mean statistic= 2.3852), buying livestock animals (cow, sheep,. goat, pig) (mean statistic= 2.2734) , buying or extending the land (mean statistic= 2.2500) and strengthening their roles in decisions making committees (At village level, cell level, sector level, district…) (mean statistic= 2.0350). The findings also discovered that the use of agricultural financing has contributed on buying of new household furniture (Sofa, fridge…) and transportation assets (a bike or motorbike or car…(specify) at mean static of 1.52531 and 0.1751 respectively. Therefore, based on the above results, the farm households' decisions to participate to the use of agricultural financing in potato production have contributed more to poverty reduction. They have increased income and improved the household wellbeing through enhanced linkage with the marketplace and abilities to increase their productivity.

4.8 Focus group and key informants' discussions

The discussion with the credit officers of important lending institutions involved in agricultural financing comprising of Banks (BPR, BK, KCB, Urwego Opportunity Bank.and Unguka Bank Ltd) and MFI's (4 Umurenge SACCO) were held on wide spectrum of issues relating to loans provided to farmers. The credit officers revealed that their prime mission is to finance high profitable activities with limited risks, but they lack profitability of investing in agriculture with full of uncontrollable risks. Despite the risks associated with agriculture, banks and other lending institutions have extended loans to farmer cooperative organizations at 100 %, individual farmers at 80 %, input traders at 60 %, processors at 40% and wholesalers at 20 %. The identified bottlenecks inhibiting them to finance potato farmers include high level of unpaid loans linked to asymmetric information. Lending institutions fail to collect accurate information on farmers as regarding to proper use and repayment capacity of the contracted loans. High transaction costs linked to poor infrastructure to reach the smallholder farmers, high borrowing rate from the central bank, inadequate collaterals by many farmers, much fluctuation of potato production and market price for potato, limited knowledge and skills in financial management like utilization and management of the loans, keeping business records and producing financial reports.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

This chapter contains conclusion, recommendations based on the study objectives as well as policy implication of the study.

5.1 Summary

The main results from descriptive statistics revealed that the mean age of sampled farmers was 41.49 years ranging between 26 years and 63 years. The mean age of non-participants being 41.47 years while mean age of participants being 41.71 years.

Probit model estimates pointed out that sex and age were significant at 1 % and 10 % respectively. The sex and age are important factors to influence farm household head's decision to participate and use of agricultural finance. This study indicated that female headed households were more likely to receive agricultural loan than male headed households. It was also discovered that the farmers' willingness to participate and use of agricultural loans increased with age. Furthermore, a positive and significant correlation was discovered between household income and farm household use of the agricultural financing. Besides that, the level of education of the household head had a positive influence on the farm household's participation in the use of agricultural financing. This implies that well educated farm household heads have the abilities to adopt the advanced production techniques as well as to decide whether to use loans or not, to boost farm productivity.

The study estimated the effect of use of agricultural credit on potato production. The effect was estimated using the average treatment effect on the treated (ATT). The average treatment effect on the untreated (ATU) is calculated to indicate the counterfactual scenarios for non-use. The ATE measures the difference in average outcomes between using agricultural credit and its counterfactual scenario of not using agricultural credit. The study found that quantity of potato harvested for households that used agricultural credit was approximately 5150 kg. On the other hand, the observed quantities of potato harvested by non-participants to agricultural credit were 1658 kg. This could imply that households that allocated credit to potato production produced approximately 211 % (about 3492 kg) more potato output than households that did not allocate credit to potato production.

Furthermore, the results obtained from Kernel and Nearest neighbour matching algorithms revealed that that using agricultural credit had a positive influence on the quantity of potato harvested. The ATT for results obtained from kernel matching algorithm was 2.48 tonnes.

The results also showed that the limited investments would constrain the access to improved seeds and fertilizers, efficient workers and limited land capacities for all non-participants to agricultural financing.

The DHM estimates were used to determine the factors influencing farm household participation in the potato market outlets. The findings discovered that farm household' sex had a positive and significant influence on his/her decisions to participate in the potato market. The partial effect for sex is 0.071, suggesting that male-headed households have 7.1 percentage more chances of participating in the market than female-headed household. Furthermore, at 1 % significant level, the findings discovered that market participation was positively and significantly related to membership to farming organizations . In other words, members of potato farmer groups had more chances of participating in the output market than non-group members.

Moreover, the study's findings showed that sex, market price, farm size, and agricultural credit all had a significant and positive influence on farm household participation in the market. The findings reinforced the importance of encouraging smallholder farm households to use agricultural financing approach to easily have access to farming inputs, increase productivity and have access to output market.

The results from the multivariate probit model found that the probabilities for farm households to sell to processors, brokers, wholesalers, retailers, and consumers were -15.2 %, -88.4 %, -116.8 %, , -24.9 %, and -82.8 % respectively, while the probabilities to sell to collection centres and cooperatives were 76.1% and 32.3% respectively. Furthermore, the findings revealed that smallholder farm households have a 0.13 % chance of selling to all the seven market outlets, which is significantly lower than the 3.7 % chance of not selling to the seven market outlets simultaneously.

Finally, the study's findings revealed that the farm households who participated in and use agricultural financing approach had better access to agricultural inputs for potato production, which increased the productivity. They had a higher gross margins of 373,499 Rwandan Francs (USD 417) compared to 370,331 Rwandan francs (USD 414) of those who did not participate to agricultural financing. The threshold income of farm household after the access to and use of agricultural financing, has gradually increased and hence increased the abilities to meet socioeconomic farm households needs like abilities to feed the family, abilities to pay health care fees, abilities to school fees, etc. The indicators revealed that

the farmer' choice of participating in and using agricultural financing approach in potato production has improved the wellbeing of farm household members.

5.2 Conclusions

The study sought to determine the effects of agricultural value chain financing on potato productivity and market access on the farm household' livelihood in Musanze and Nyabihu Districts, Rwanda. The study's findings led to the following conclusions:

i. The study underscored the importance of socioeconomic characteristics, institutional and marketing factors for farmers' decisions of participating and using agricultural value chain financing approach. The study discovered that farm households' decisions to participate and use agricultural value chain financing are influenced by the factors that include sex, age, marital status of household head, membership to farming organizations, farm experience, household income, and distance to agricultural markets.

ii. The study also discovered that fear of borrowing, inadequate/insufficient skills in agricultural budgeting, unpredictable production, higher interest rates and charges to process the loans, financial illiteracy, inadequate/insufficient collaterals and short repayment period hampered the farm households' decisions of participating in and using the agricultural value chain financing approach to finance potato production activities.

iii. The study found that using agricultural value chain financing approach had a positive and significant effect on the quantity of potatoes harvested. It also found that the quantity of potato harvested for households that used agricultural credit was approximately 5.150 metric tons. On the other hand, the observed quantities of potato harvested by non-participants to agricultural credit were 1.658 metric tons. This could imply that households that allocated credit to potato production produced approximately 211 % (about 3.492 metric tons) more potato output than households that did not allocate credit to potato production. The findings also showed that limited investment would be the main constraints for non- participants to agricultural financing to access improved seeds and fertilisers.

iv. Findings revealed that farmers' market participation was significantly and positively influenced by the use of agricultural credit . They also demonstrated that the extent of

market participation was higher for potato farmers who used agricultural financing than for those who did not use it.

v. The findings also found that farm household income either owned or borrowed may influence the potato farmers' choice decisions of selling to consumer, retailer, wholesaler, cooperative, collection centres and processors market outlets.

vi. Finally, the study found that the farm households' willingness to participate and use agricultural financing in potato production enabled them to have access to farming inputs for potato production and increase of potato productivity. It also boosted linkages with the outputs markets as well as increased income and hence enhanced the wellbeing of farm household members.

5.3 Recommendations

The study recommends the followings:

i. To upgrade the potato farmers ' education in the areas of farming systems and marketing so as to produce and deliver quality products

ii. To strengthen smallholder farmers cooperatives for increasing the yield and improving the quality of potatoes, improving access to market information and improving the linkages with high valued outputs markets.

iii. To promote the dynamism of agricultural value chain financing, commercial banks should develop the long-term loan products tailored to smallholder farmers' needs in order to finance the production and marketing activities

iv. Strengthening the relationship between banks and small-scale farmers to facilitate them to access to adequate financial products, to remove or minimize the constraints that prevent all categories of farmers both small and large farmers from having equal access to agricultural loans.

v. The study recommends the government to enact flexible policies such as lowering borrowing rates, encouraging financial providers to expand their financial investments in potato value chain at lower interest rate.

vi. To reduce the risks associated with financing agricultural activities, the government should enact the law establishing basket funds with special goal of facilitating smallholder farmers' access to credit at low interest rate.

vii. Government in collaboration with its stakeholders in potato value chain should establish the organized mechanisms to simplify the process for smallholder farmers to obtain market information and guaranteed access to valued markets.

viii. Government should enact the law regulating potato production, investment and marketing to promote the potato value chain development in Rwanda.

REFERENCES

Abate, T. M., Mekie, T. M., & Dessie, A. B. (2019). Determinants of market outlet choices by smallholder teff farmers in Dera district, South Gondar Zone, Amhara National Regional State, Ethiopia: a multivariate probit approach. *Journal of Economic Structures*, *8*(1), 39. https://doi.org/10.1186/s40008-019-0167-x

Abayneh, Y., & Tefera, T. (2014). Factors influencing market participation decision and extent of participation of bean farmers in Meskan District , Ethiopia. *International Journal of Management and Development Studies Www.Ijmds.Com*, *2*(August 2013), 17–23.

Abdul-Hanan, A., Hananu, B., & Hudu, Z. (2015). Factors influencing agricultural credit demand in Northern Ghana. *African Journal of Agricultural Research*, *10*(7), 645–652. https://doi.org/10.5897/AJAR2014. 9330

Abdullah, S., Rabbi, F., Ahamad, R., Ali, S., Ali, A., Ahmad, W., & Ilyas, A. (2017). Determinants of Commercialization and its impact on the Welfare of Smallholder rice Farmers by using Heckman ' s two-stage approach. *Journal of the Saudi Society of Agricultural Sciences*, *18*(2), 535–555. https://doi.org/10.1016/j.jssas.2017.06.001

Abebe, G. K., Bijman, J., & Royer, A. (2016). Are middlemen facilitators or barriers to improve smallholders' welfare in rural economies? Empirical evidence from Ethiopia. *Journal of Rural Studies*, *43*(2016), 203–213. https://doi.org/10.1016/j.jrurstud.2015.12.004

Abu, B. M. (2015). Groundnut market participation in the Upper West Region of Ghana. *Ghana Journal of Development Studies*, *12*(1-2), 106-124. https://doi.org/10.4314/gjds.v12i1-2.7

ADB. (2012). *Support for Agricultural Value Chain Development-Evaluation Knowledge Study October 2012*. https://www.adb.org/sites/default/files/evaluation-document/35898/files/eks-agriculturalvaluechain.pdf

Adeoti, A. I., Oluwatayo, I. B., & Soliu, R. O. (2014). Determinants of Market Participation among Maize Producers in Oyo State , Nigeria. *British Journal of Economics, Management & Trade*, *4*(7), 1115–1127.

Afriat, S. N. (1972). Efficiency Estimation of Production Functions. *International Economic Review*, *13*(3), 568–598.

Agunuwa, V. E., Inaya, L. (CNA), & Proso, T. (2015). Impact of Commercial Banks ' Credit o n Agricultural Productivity in Nigeria (Time Series Analysis 1980 - 2013).

International Journal of Academic Research in Business and Social Sciences, *5*(11), 337–350. https://doi.org/10.6007/IJARBSS/v5-i11/1921

Ahn, S., Kyaw, N. N., & Lee, S. H. (2018). Analysis of the Factors Influencing Market Participation among Smallholder Rice Farmers in Magway Region , Central Dry Zone of Myanmar. *Sustainability*, *10*(4441), 1–15. https://doi.org/10.3390/su10124441

Aigner, D. J., & Chu, S. F. (1968). American Economic Association On Estimating the Industry Production Function. *The American Economic Review*, *58*(4), 826–839.

Aigner, D., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37.

Akudugu, M. A. (2012). Estimation of the Determinants of Credit Demand by Farmers and Supply by Rural Banks i n Ghana ' s Upper East Region. *Asian Journal of Agriculture and Rural Development*, *2*(2), 189–200.

Al-Hassan, R. M., Sarpong, D. B., & Mensah-Bonsu, A. (2006). *Linking Smallholders to Markets*. International Food Policy Research Institute.Ghana Strategy Support Program(GSSP).

Alderman, H., Chiappori, P. A., Haddad, L., Hoddinott, J., & Kanbur, R. (1995). Unitary versus collective models of the household: Is it time to shift the burden of proof? *The World Bank Research Observer*, *10*(1), 1-19.

Ali, D. A., Deininger, K., & Duponchel, M. (2014). *Credit Constraints , Agricultural Productivity , and Rural Nonfarm Participation Evidence from Rwanda* (Issue February). http://documents1.worldbank.org/curated/en/501541468306236166/pdf/WPS6769.pdf

Arene, C. J. (1993). An analysis of loan repayment potentials of smallholder soyabean group farmers in Nigeria. *Quarterly Journal of International Agriculture*, *32*(1), 160–169.

Arinloye, D.-D. A., Pascucci, S., Linnemann, A. R., Coulibaly, O. N., Hagelaar, G., & W F Omta, O. S. (2015). Marketing Channel Selection by Smallholder Farmers. *Journal of Food Products Marketing*, *21*(4), 337–357.

Asante-Addo, C., Mockshell, J., Zeller, M., Siddig, K., & Egyir, I. S. (2017). Agricultural credit provision: what really determines farmers' participation and credit rationing? *Agricultural Finance Review*, *77*(2), 239–256. https://doi.org/10.1108/AFR-02-2016-0010

Asfaw, S. (2010). Estimating Welfare Effect of Modern Agricultural Technologies : A Micro-Perspective from Tanzania and Ethiopia May 27 , 2010 (First Version) Abstract.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 1–27.

Asfaw, S., & Shiferaw, B. (2010). Agricultural Technology Adoption and Rural Poverty : Application of an Endogenous Switching Regression for Selected East African Countries. *Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference*.

Austin, P. C. (2011). An Introduction to Propensity Score Methods for Reducing the Effects of Confounding in Observational Studies. *Multivariate Behavioral Research*, *46*(3), 399–424. https://doi.org/10.1080/00273171.2011.568786

Awotide, B. ., Abdoulaye, T., Alene, A., & Manyong, V. . (2015). Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria. *International Conference of Agricultural Economists (ICAE)*.

Baffoe, G., & Matsuda, H. (2015). Understanding the Determinants of Rural Credit Accessibility: The Case of Ehiaminchini, Fanteakwa District, Ghana. *Journal of Sustainable Development*, *8*(6), 183–195.

Bai, S., & Jia, X. (2022). Agricultural Supply Chain Financing Strategies under the Impact of Risk Attitudes. *Sustainability*, 14(14), 8787. https://doi.org/10.3390/su14148787

Baker, J. L. (2000). *Evaluating the Impact of Development Projects on Poverty*. http://siteresources.worldbank.org/INTISPMA/Resources/handbook.pdf

Baltas, G., & Doyle, P. (2001). Random utility models in marketing research: A survey. *Journal of Business Research*, *51*(2), 115–125. https://doi.org/10.1016/S0148-2963(99)00058-2

Barling, D., Samoggia, A., & Olafsdottir, G. (2022). Dynamics of Food Value Chains: Resilience, Fairness and Sustainability. *Agriculture*, 12(5), 720. https://doi.org/10.3390/agriculture12050720

Barrett, C. B., Bachke, M. E., Bellemare, M. F., Michelson, H. C., Narayanan, S., & Walker, T. F. (2012). Smallholder participation in contract farming: Comparative evidence from five countries. *World Development*, *40*(4), 715–730.

Battese, G. E., & Coelli, T. . (1995). A model for Technical Inefficiency effects in a Stochastic Frontier Production Function. *Empirical Economics*, *20*, 325–332. https://doi.org/10.1007/BF01205442

Baumann, P. (2000). *Equity and Efficiency in Contract Farming Schemes: The Experience of Agricultural tree Crops*. https://doi.org/ISBN 0 85003 501 5

Becker, G. S. (1993). *A Treatise on the Family* (Enlarged E). Harvard University Press.

Becker, S. O., & Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. *The Stata Journal*, *2*(4), 358–377.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization*, *22*(8–9), 1237–1263. https://doi.org/10.1016/J.IJINDORG.2004.08.001

Beninger, D., & Laisney, F. (2002). *Comparison Between Unitary and Collective Models of Household Labor Supply With Taxation* (Issue 02). https://madoc.bib.uni-mannheim.de/380/1/dp0265.pdf

Bernard, T., & Spielman, D. J. (2009). Reaching the rural poor through rural producer organizations? A study of agricultural marketing cooperatives in Ethiopia. *Food Policy*, *34*(1), 60–69. https://doi.org/10.1016/j.foodpol.2008.08.001

Bijman, J. (2008). Contract farming in developing countries: An overview. In *Working Paper, Wageningen University, Wageningen, The Netherlands*. https://doi.org/10.2499/9780896292130_04

Brenneis, K., & Fortenbacher, D. (2016). *Modernization Options for the Potato Value Chain in Kenya and Nigeria.* German Government for International cooperation for sustainable development (GIZ). http://www.npck.org/Books/Final PIA intervention booklet.pdf

Brown, S., Lecumberri, N., & Mutungo, N. (2012). *Rwanda Livelihood Zones and Descriptions June 2012*. www.fews.net

Browning, M., & Chiappori, P.-A. (1998). Efficient Intra-Household Allocations : A General Characterization and Empirical Tests. *Econometrica*, *66*(6), 1241–1278. http://www.jstor.org/stable/2999616

Burke, W. J. (2009). Fitting and interpreting Cragg ' s tobit alternative using Stata. *The Stata Journal*, *9*(4), 584–592.

Caliendo, M., & Kopeinig, S. (2008). Some Practical Guidance for the Implementation of Propensity Score Matching. *Journal of Economic Surveys*, *22*(1), 31–72.

Cappellari, L., & Jenkins, S. P. (2003). Multivariate probit regression using simulated maximum likelihood. *The Stata Journal*, *3*(3), 278–294.

Chen, B., & Liao, S. (2015). The Role of Agricultural Productivity on Structural Change. *Review of Development Economics*, *19*(4), 971–987. https://doi.org/10.1111/rode.12189

Chiappori, Pierre Andre. (1992). Collective Labor Supply and Welfare. *Journal of Political Economy*, *100*(3), 437–467.

Chiappori, Pierre Andre. (1997). Introducing Household Production in Collective Models of Labor Supply. *Journal of Political Economy*, *105*(1), 191–209.

Chiappori, Pierre André, & Donni, O. (2009). *Non-unitary Models of Household Behavior: A Survey of the Literature*. IZA Discussion Papers, No. 4603.

Coates, M., & Hofmeister, R. (2013). Financing Agriculture: Selected Approaches for the Engagement of Commercial Finance. In B. Torsten & S. Munzele Maimbo (Eds.), *Financial Sector Development in Africa: Opportunities and Challenges* (pp. 83–106). World Bank.

Cochran, W. G. (1977). *Sampling Techniques* (Third Edit). John Wiley & Sons, Inc. https://glad.geog.umd.edu/Potapov/_Library/Cochran_1977_Sampling_Techniques_Third_Edition.pdf

Conway, G., Carsalade, H., Oniango, R., Toulmin, C., Hazell, P., & Pingali, P. (2014). Small and growing Entrepreneurship in African Agriculture: a Montpellier Panel report. *African Journal of Food, Agriculture, Nutrition and Development*, *14*(4), 2-26.

Cragg, J. G. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica*, *39*(5), 829–844.

Crawford, E. W., Jayne, T. ., & Kelly, V. A. (2006). Alternative Approaches for Promoting Fertilizer Use in Africa. In *Agriculture and Rural Development-Discussion paper 22*.

Creswell, J. W. (2009). *Research Design. Qualitative, Quantitative and Mixed Methods Approaches* (Third Edit). SAGE Publications, Inc.

Crossley, P., Chamen, T., Kienzle, J., & Infrastructure and Agro-Industries Division. (2009). Rural transport and traction enterprises for improved livelihoods. In *Diversification booklet* (Issue no 10). ftp://ftp.fao.org/docrep/fao/011/i0525e/i0525e.pdf

Dary, S. K. (2017). Trade Credit Financing in African Agro-Food Manufacturing Industry:Incidence and Motives. *2017 Annual Meeting, February 4-7, 2017*.

Dehejia, R. H., & Wahba, S. (2002). Propensity Score Matching Methods for Noneexpermental Caual Studies. *Review of Economics and Statistics*, *84*(1), 151–161.

Devaux, A., Torero, M., Donovan, J., & Horton, D. (2018). Agricultural innovation and inclusive value-chain development: a review. *Journal of Agribusiness in Developing and Emerging Economies*, 8(1), 99-123. https://doi.org/10.1108/JADEE-06-2017-0065

Diagne, A., & Zeller, M. (2001). Access to Credit and Its Impact on Welfare in Malawi. *(Research Report 116)*, 1–168. https://doi.org/116

Dlamini-Mazibuko, B. P., Ferrer, S., & Ortmann, G. (2019). Factors affecting the choice of

marketing outlet selection strategies by smallholder farmers in Swaziland. *African Journal of Science, Technology, Innovation and Development*, *11*(5), 569–577. https://doi.org/10.1080/20421338.2018.1554323

Dohcheva, D. (2009). Credit Rationing in Agricultural Credit markets in Bulgaria. *Trakia Journal of Sciences*, *7*(3), 57–62.

Donkor, E., Onakuse, S., Bogue, J., & De Los Rios-Carmenado, I. (2018). Determinants of farmer participation in direct marketing channels: A case study for cassava in the Oyo state of Nigeria. *Spanish Journal of Agricultural Research*, *16*(2). https://doi.org/10.5424/sjar/2018162-12076

Djoumessi, Y. F., Kamdem, C. B., & Ndeffo Nembot, L. (2020). Moving off agrarian societies: Agricultural productivity to facilitate economic transformations and non-agricultural employment growth in sub-Saharan Africa. *Journal of International Development*, 32(3), 324-341. https://doi.org/10.1002/jid.3455

Dutta, B. K. (2003). *Theories of share cropping : evidence from North-East India*. Mittal Publications Pvt. Ltd.

Duy, Q. V. (2015). Access to Credit and Rice Production Efficiency of Rural Households in the Mekong Delta. *Sociology and Anthropology*, *3*(9), 425–433. https://doi.org/10.13189/sa.2015.030901

EAFF. (2013). *Agriculture Financing Models and Approaches for Farmers and Farmer Organizations in Eastern Africa*.

Eaton, C., & Shepherd, A. W. (2001). *Contract farming: Partnerships for growth (No 145)*. Food and Agriculture Organization. https://doi.org/ISSN 000-000

Egbetokun, O. A., Shittu, B. A., & Ayoade, M. O. (2017). Determinants of Market Participation Among Maize Farmers in Ogbomoso Zone, Oyo State, Nigeria. *Cercetari Agronomice in Moldova*, *50*(1), 109–118. https://doi.org/10.1515/cerce-2017-0010

Enenche E.A, Ohen S.B, & Umeze G. (2014). The Effect of Agricultural Credit Guarantee Scheme Fund (ACGSF) on Production Efficiency of Rural Farmers in Benue State, Nigeria. *Global Journal of Science Frontier Research*, *14*(10), 46–54.

Enimu, S., Eyo, E. O., & Ajah, E. A. (2017). Determinants of loan repayment among agricultural microcredit finance group members in Delta state, Nigeria. *Financial Innovation*, *3*(1), 1-12. https://doi.org/10.1186/s40854-017-0072-y

Europian Commision. (2013). *Income pooling and equal sharing within the household — W hat can we learn from the 2010 EU-SILC module?* (2013 Editi). Luxembourg:

Publications Office of the European Union.

Fafchamps, M., & Hill, R. V. (2005). Selling at the farmgate or traveling to market. *American Journal of Agricultural Economics*, *87*(3), 717–734. https://doi.org/10.1111/j.1467-8276.2005.00758.x

Falkingham, J & Baschieri, A. (2005). Gender and Poverty: How we can be misled by the unitary Model os Household Resources- The case of Tajikistan. *Southampton Statistical Sciences Research Institute Applications & Policy Working Paper A04 / 21*. https://eprints.soton.ac.uk/13984/

FAO. (2008). *The potato world: International Year of the Potato 2008*. FAO. http://www.fao.org/potato-2008/en/potato/origins.html

FAO. (2012). *The State of Food and Agriculture: Investing in Agriculture for a Better Future*. http://www.fao.org/resources/infographics/infographics-details/en/c/174175/

FAO. (2016). *Strengthening linkages between small actors and buyers in the Roots and Tubers sector in Africa*. http://www.fao.org/3/a-bc578e.pdf

FAOSTAT. (2022). *World Potato Statistics | PotatoPro*. Food Innovation Online Corp. https://www.potatopro.com/world/potato-statistics

Fernando, R. (2011). *Logit , Probit and Tobit : Models for Categorical and Limited Dependent Variables*.

Ferrari, L., Fromm, I., Jenny, K., Muhire, A., & Scheidegger, U. (2017). Formal and informal seed potato supply systems analysis in Rwanda. *Future Agriculture: Social-Ecological Transitions and Bio-Cultural Shifts Organised by the University of Bonn and the Centre for Development Research. Presented at the Tropentag 2017.*, 1–5.

Friedlander, D., & Robins, P. K. (1995). Evaluating Program Evaluations: New Evidence on Commonly Used Nonexperimental Methods. In *The American Economic Review* (Vol. 85, pp. 923–937). American Economic Association. https://doi.org/10.2307/2118240

Galdo, J. C. A., Smith, J., & Black, D. (2008). Bandwidth Selection and the Estimation of Treatment Effects with Unbalanced Data. In J. C. Galdo, J. Smith, & D. Black (Eds.), *Econometric Evaluation of Public Policies: Methods and Applications* (Issue 91, pp. 189–216). GENES on behalf of ADRES. https://www.jstor.org/stable/27917245

Gashayie, A., & Manjit, S. (2015). *Agricultural Finance Constraints and Innovative Models Experience for Ethiopia : Emprical Evidance from Developing Countries*. *6*(7), 39–50.

Gebre, G. G., Isoda, H., Rahut, D. B., Amekawa, Y., & Nomura, H. (2021). Gender gaps in market participation among individual and joint decision-making farm households:

Evidence from Southern Ethiopia. *The European Journal of Development Research*, *33*(3), 649-683. https://doi.org/10.1057/s41287-020-00289-6

Girabi, F., & Mwakaje, A. E. G. (2013). Impact of microfinance on smallholder farm productivity in Tanzania: The case of Iramba district. *Asian Economic and Financial Review*, *3*(2), 227–242.

Gliem, J. A., & Gliem, R. R. (2003). Calculating , Interpreting , and Reporting Cronbach ' s Alpha Reliability Coefficient for Likert-Type Scales. *Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.*, *1992*, 82–88. https://scholarworks.iupui.edu/handle/1805/344

GoR. (2013). *Economic Developmnt and Poverty Reduction Strategy II 2013-2018*. www.glcmc.com

Gouri, K. V, & Mahajan, V. (2017). Different Models of Financing Small Farmers' Agricultural Value Chains. *Financing agricultural value chain in India*.33–53. Springer, Singapore. https://doi.org/10.1007/978-981-10-5957-5

Green, C. J., Kirkpatrick, C. H., & Murinde, V. (2006). Finance for Small Enterprise Growth and Poverty Reduction in Developing Countries. *Journal of International Developement*, *18*, 1017–1030.

Greene, W. H. (2002). *Econometric analysis* (5th edition). Prentice Hall.

Greene, W. H. (2008). *Econometric Analysis* (6th edition). Prentice Hall.

Gujarati. (2004). *Basics Econometrics* (U. McGraw-Hill, New York (Ed.)). Econometrics, Basic.

Haddad, L., Hoddinott, J., & Alderman, H. (1994). *Intrahousehold Resource Allocation: An Overview*. *81*(2), 1–94.

Hardesty, S. D., & Leff, P. (2010). Determining marketing costs and returns in alternative marketing channels. *Renewable Agriculture and Food Systems*, *25*(1), 24–34. https://doi.org/10.1017/S1742170509990196

Heinen, S. (2022). Rwanda's Agricultural Transformation Revisited: Stagnating Food Production, Systematic Overestimation, and a Flawed Performance Contract System. *The Journal of Development Studies*, 1-21. https://doi.org/10.1080/00220388.2022.2069494).

Henriksen, L., Riisgaard, L., Ponte, S., Hartwich, F., & Kormawa, P. (2010). *Agro-Food Value Chain Interventions in Asia: A review and analysis of case studies*.

Hill, R. V. (2010). Investment and abandonment behavior of rural households: An empirical

investigation. *American Journal of Agricultural Economics*, *92*(4), 1065–1086. https://doi.org/10.1093/ajae/aaq055

Hoddinott, J., & Haddadt, L. (1995). Does Female Income Share Influence Household Expenditures? Evidence from Cote d'Ivoire. *Oxford Bulletin of Economics and Statistics*, *57*(1), 0305–9049.

Huang, C., Chan, F. T., & Chung, S. H. (2022). Recent contributions to supply chain finance: towards a theoretical and practical research agenda. International Journal of Production Research, 60(2), 493-516. https://doi.org/10.1080/00207543.2021.1964706

Imbens, G. W. (2004). *Nonparametric Estimation of Average Treatment Effects Under Exogeneity : A Review* *. *86*(February), 4–29.

Ingabire, C., Mshenga, M. P., Langat, K., Bigler, C., Musoni, A., Butare, L., & Birachi, E. (2017). Towards commercial agriculture in Rwanda: Understanding the determinants of market participation among smallholder bean farmers. *African Journal of Food, Agriculture, Nutrition and Development*, *17*(4), 12492–12508. https://doi.org/10.18697/ajfand.80.16825

IPAR (The Institute of Policy Analysis and Research). (2015). *Annual A nalysis of Rwanda ' s Agriculture Budget Expenditure 2015-2016*. http://www.ipar-rwanda.org/IMG/pdf/annual_analysis_of_rwanda_s_agriculture_budget_expenditure_2015-2016.pdf

Isiorhovoja, R. A., & Chukwuji, C. O. (2009). Effects of the operations of the agricultural credit guarantee scheme fund on cash crops. *International Journal of Rural Studies (IJRS)*, *16*(1), 2–7.

Janssens, S. R. M., Wiersema, S. G., Goos, H., & Wiersma, W. (2013). *The value chain for seed and ware potatoes in Kenya Opportunities for development*. https://library.wur.nl/WebQuery/wurpubs/reports/443794

Jarén, C., López, A., & Arazuri, S. (2016). Advanced Analytical Techniques for Quality Evaluation of Potato and Its Products. *Advances in Potato Chemistry and Technology*, 563–602. Elsevier. https://doi.org/10.1016/B978-0-12-800002-1.00019-4

Kassaw, M. H., Birhane, Z., & Alemayehu, G. (2019). Determinants of market outlet choice decision of tomato producers in Fogera woreda, South Gonder zone, Ethiopia. *Cogent Food & Agriculture*, *5*(1), 1–20. https://doi.org/10.1080/23311932.2019.1709394

Kim, S. K., Marshall, F., & Dawson, N. M. (2022). Revisiting Rwanda's agricultural intensification policy: Benefits of embracing farmer heterogeneity and crop-livestock

integration strategies. *Food Security*, 1-20.

Key, N., Sadoulet, E., & Janvry, A. De. (2000). Transactions Costs and Agricultural Household Supply Response. *American Journal of Agricultural Economics*, *82*(May), 245–259.

Kgowedi, M., Makhura, M., & Coetzee, G. (2002). *Factors Distinguishing The Choice Of Moneylenders And Non-Moneylenders In MJ Kgowedi , MN Makhura & GK Coetzee Working paper : 2002-07 University of Pretoria* (Issue January).

Khapayi, M., & Celliers, P. R. (2016). Factors Limiting and Preventing Emerging Farmers To Progress to Commercial Agricultural Farming in the King William's Town Area of the Eastern Cape Province, South Africa. *South African Journal of Agricultural Extension*, *44*(1), 25–41. https://doi.org/http://dx.doi.org/10.17159/2413-3221/2016/v44n1a374

King, G., & Nielsen, R. (2016). Why propensity score should not be used for matching. In *Mimeo* (Issue 617). http://gking.harvard.edu/files/gking/files/psnot.pdf

KMP. (2013). Warehouse Receipt System: Providing collateral and maximizing value. *Experiences from East and Southern Africa- ESA*, 7–14.

Kombo, D. K. ., & Tromp, D. L. (2006). *Proposal and thesis writing: An introduction*. Paulines Publications Africa.

Konlambigue, A. (2007). Financing agricultural inputs in Northern Togo through an inventory credit system : an economic analysis of institutional response. *AAAE Conference Proceedings*, 119–124. http://ageconsearch.umn.edu/bitstream/52100/2/Konlambigue.pdf

Kosgey, Y. K. K. (2013). Agricultural Credit Access by Grain Growers in Uasin-Gishu County, Kenya. *IOSR Journal of Economics and Finance*, *2*(3), 36–52. https://doi.org/10.9790/5933-0233652

Kyomugisha, H., Sebatta, C., & Mugisha, J. (2018). Potato market access , marketing efficiency and on-farm value addition in Uganda. *Scientific African*, *1*, e00013. https://doi.org/10.1016/j.sciaf.2018.e00013

Leroux, M. N., Schmit, T. M., Roth, M., & Streeter, D. H. (2010). Evaluating marketing channel options for small-scale fruit and vegetable producers. *Renewable Agriculture and Food Systems*, *25*(1), 16–23. https://doi.org/10.1017/S1742170509990275

Lokshin, M., & Sajaia, Z. (2004). Maximum likelihood estimation of endogenous switching regression models. *The Stata Journal*, *4*(3), 282–289.

Lukytawati, A. (2009). Factors Influencing Participation and Credit Constraints of a Financial

Self-Help Group in a Remote Rural Area: The case of rosca and ASCRA in Kemang Village West Java. *Journal of Applied Sciences*, *9*(11), 2067–2077.

Maddala, G. S. (1983). Model with self-selectivity. *Limited-Dependent and Qualitative Variables in Economics*, 257–291.

Manen, B. van, Duursma, M., Harms, J., Mallek, A., Diallo, B., & Jessop, R. (2012). Creating Access to Agricultural Finance. Based on a horizontal study of Cambodia, Mali, Senegal, Tanzania, Thailand and Tunisia. *The Savoir*, *14*(July), 1–119. https://doi.org/10.5539/jas.v6n11p63

Marenya, P. P., Kassie, M. B., Jaleta, M. D., & Rahut, D. B. (2017). Maize Market Participation among Female- and Male-Headed Households in Ethiopia. *Journal of Development Studies*, *53*(4), 481–494. https://doi.org/10.1080/00220388.2016.1171849

Markelova, H., & Mwangi, E. (2010). Collective action for smallholder market access: Evidence and implications for Africa. *Review of Policy Research*, *27*(5), 621–640. https://doi.org/10.1111/j.1541-1338.2010.00462.x

Martey, E., Al-hassan, R. M., & Kuwornu, J. K. M. (2012). Commercialization of Smallholder Agriculture in Ghana : A Tobit Regression Commercialization of smallholder agriculture in Ghana : A Tobit regression analysis. *African Journal of Agricultural Research*, *7*(14), 2131–2141. https://doi.org/10.5897/AJAR11.1743

Mattila-Wiro, P. (1999). *Economic Theories of the Household: A Critical Review* (No. 159; Working Paper).

Mbitsemunda, J. P. K., & Karangwa, A. (2017). Analysis of Factors Influencing Market Participation of Smallholder Bean Farmers in Nyanza District of Southern Province, Rwanda. *Journal of Agricultural Science*, *9*(11), 99. https://doi.org/10.5539/jas.v9n11p99

Mcmichael, P. (2013). Value-chain Agriculture and Debt Relations: contradictory outcomes. *Third World Quarterly*, *34*(4), 671–690. https://doi.org/10.1080/01436597.org/10.1080/01436597.2013.786290

Melese, T., Goshu, D., & Tilahun, A. (2018). Determinants of outlet choices by smallholder onion farmers in Fogera district Amhara Region, Northwestern Ethiopia. *Journal of Horticulture and Forestry*, *10*(3), 27–35. https://doi.org/10.5897/jhf2018.0524

Miller., C. (2004). Examining Design and Innovations in Rural Finance For Addressing Current and Future Challenges:Twelve Key Challenges in Rural Finance. In *FAO Rural Finance Workshop-SEEP Pre-Event October 26, 2004*.

Miller, C. (2011). *Agricultural Value Chain Finance Strategy and Design-Technical Note*. http://www.ruralfinanceandinvestment.org/sites/default/files/AgVCF_Tech_Note_pdf.pdf

MINECOFIN. (2013). *Rwanda: Economic Developement and Poverty reduction Strategy 2013-2018*.

Mitchell, T. (2011). Middlemen, Bargaining and Price Information: Is Knowledge Power? *London School of Economics and Political Science*, 1–43.

Mugabo, J., Nyamwaro, S. O., Kalibwani, R., Tenywa, M. M., Buruchara, R., & Oluwole, F. (2018). *Innovation Opportunities in Potato Production in Rwanda.* Forum for Agricultural Research in Africa (FARA), Report.. https://library.faraafrica.org/wp-content/uploads/2019/10/FRR-Volume-2-No-16-2018-Innovation-Opportunities-in-Potato-Production-in-Rwanda.pdf

Mohammad, N. (1992). *New dimensions in agricultural geography*. Ashoke Kumar Mittal Concept Publishing company. https://newbooksinpolitics.com/political/new-dimensions-in-agricultural-geography-landuse-and-agricultural-planning/

Monson, J., Mainville, D., & Kuminoff, N. (2008). The decision to direct market: An analysis of small fruit specialty-product markets in Virginia. *Journal of Food Distribution Research*, *39*(2), 1–11.

Monteros-Altamirano, Á., Yumisaca-Jiménez, F., Aucancela-Huebla, R., Coronel, J., Corozo-Quiñonez, L., & Cunguán, K. (2022). Potato landraces and their wild relatives in 3 micro-centers of diversity in Ecuador: farmers' perception and ecogeography. *Genetic Resources and Crop Evolution*, *69*(3), 1069-1087.

Mpandeli, S., & Maponya, P. (2014). *Constraints and Challenges Facing the Small Scale Farmers in Limpopo Province , South Africa*. *6*(4), 135–143. https://doi.org/10.5539/jas.v6n4p135

Mugisha, I. R. (2022, July 2). The smallholder farmers feeding the long food supply chain in Rwanda. The East African. Retrieved November 14, 2022, from https://www.theeastafrican.co.ke/tea/news/east-africa/smallholder-farmers-feeding-food-supply-chain-in-rwanda

Muhinyuza, J. B., Shimelis, H., Melis, R., Sibiya, J., & Nzaramba, M. N. (2012). Participatory assessment of potato production constraints and trait preferences in potato cultivar development in Rwanda. *International Journal of Development and Sustainability*, *1*(2), 358–380.

Mujawamariya, G., & Achandi, E. L. (2016). Market participation by smallholder rice farmers in Tanzania : a double hurdle analysis. *Studies in Agricultural Economics 118, 118*, 112–115.

Mshenga, P., Aku, A., Afari-sefa, V., & Ochieng, J. (2018). Effect of market access provided by farmer organizations on smallholder vegetable farmer ' s income in Tanzania. *Cogent Food & Agriculture*, *4*(1), 1–13. https://doi.org/10.1080/23311932.2018.1560596

Musanze District. (2013). *District developement plan*.

Nelson, M. ;, Walton, M., Sikinyi, E., & Urinzwenimana, C. (2016). *Rwanda Early Generation Seed study. Country Report*.

NETAFIM. (2017). *Grow Higher potato yields with consistent size and shape via precision irrigation*. https://www.netafim.co.za/offering/irrigation/agriculture/field/potato/?id=80

NISR-EICV3. (2012a). *Rwanda Fourth Population and Housing Census-District profile: Musanze*.

NISR-EICV3. (2012b). *Rwanda Fourth Population and Housing Census-District profile: Nyabihu*.

NISR. (2015). *Seasonal Agriculture Survey*.

NISR. (2017). *Gross Domestic Product and its structure In the first quarter of 2017*.

NISR. (2018). *Seasonal AgriculturalSurvey 2017*.

NISR, & MINECOFIN. (2014). *Rwanda Fourth Population and Housing Census, 2012. Thematic Report: Population size, structure and distribution*.

Nosiru, M. O. (2010). Microcredits and Agricultural Productivity in Ogun State, Nigeria. *World Journal of Agricultural Sciences*, *6*(3), 290–296.

Nshimiyimana, J. C., Senkesha, N., Masengesho, J., & Kakuhenzire, R. (2015). Evaluation of two major potato varieties under aeroponic conditions in Rwanda. Transforming potato and sweet potato value chains for food and nutrition security. *Triennial Congress of the African Potato Association-. Naivasha (Kenya) 30 Jun - 9 Jul 2013.*

Nxumalo, K. K. S., Oduniyi, O. S., Antwi, M. A., & Tekana, S. S. (2019). Determinants of market channel choice utilised by maize and sunflower farmers in the North West province, South Africa. *Cogent Social Sciences*, *5*(1). https://doi.org/10.1080/23311886.2019.1678451

Nzomo, M., & Muturi, W. (2010). The Effect of Types of Agricultural Credit Programmes on Productivity of Small Scale Farming Businesses in Kenya: A Survey of Kimilili Bungoma Sub County. *Journal of Economics and Sustainable Development*, *5*(23), 150–

160.

Oberholster, C., Adendorff, C., & Jonker, K. (2015). Financing agricultural production from a value chain perspective: Recent evidence from South Africa. *Outlook on Agriculture*, *44*(1), 49–60. https://doi.org/10.5367/oa.2015.0197

Odusola, A. (2017). Agriculture, rural poverty and income inequality in sub-saharan Africa. In UN, *Income Inequality Trends in sub-Saharan Africa: Divergence, Determinants and Consequences* (pp. 77-100). New York, USA: United Nations Development Programme (UNDP). https://www.un-ilibrary.org/content/books/9789210607100s005-c001

Ojo, M. P., & Ayanwale, A. B. (2019). Value chain financing and plantain production in Nigeria : an ex-ante approach. *Financial Innovation*, *5*(1). https://doi.org/Ojo, Mathew Paul; Ayanwale, Adeolu Babatunde (2019). Value chain financing and plantain production in Nigeria: an ex-ante approach. *Financial Innovation*, 5(1), 18–. doi:10.1186/s40854-019-0132-6

Okoboi, G. (2001). The marketing potential of Potatoes in Uganda and market opportunities for Rwanda .*International Institute of Tropical Agriculture* (Issue 10). https://betuco.be/Potato/Rwanda_Potato_Marketing.pdf

Olagunji, F., & Ajiboye, A. (2010). Agricultural lending decision: a tobit regression analysis. *African Journal of Food Agriculture, Nutrition and Development*, *10*(5), 1–27.

Olayide, S. O., & Heady, E. O. (1982). *Introduction to agricultural production economics.* Ibadan: University of Ibadan Press.

Olwande, J., & Mathenge, M. (2012). International Association of Agricultural Economists (IAAE) Triennial Conference. *Market Participation among Poor Rural Households in Kenya.*, 18–24. http://ageconsearch.umn.edu/bitstream/126711/1/Olwande.pdf

Ortiz, O., & Mares, V. (2017). The Historical, Social, and Economic Importance of the Potato Crop. In S. K. Chakrabarti, C. Xie, & J. K. Tiwari (Eds.), *The Potato Genome* (pp. 1–10). Springer, Cham.

Orwothwun, C., & Qutieshat, A. (2022). Agriculture Value Chain Finance in Uganda: A Brief Review of Literature. *Open Access Library Journal*, 9(4), 1-18. https://doi.org/10.4236/oalib.1108645

Owuor, G. (2009). Can Group Based Credit Uphold Smallholder Farmers Productivity and Reduce Poverty in Africa? Empirical Evidence from Kenya. *111 EAAE-IAAE Seminar 'Small Farms: Decline or Persistence,'* 17.

Owusu, S. (2017). Effect of Access to Credit on Agricultural Productivity: Evidence from Cassava Farmers in the Afigya-Kwabre District of Ghana. *International Journal of Innovative Research in Social Sciences & Strategic Management Techniques | IJIRSSSMT*, *4*(2), 55–57.

Paguia, F. ., Casuga, M. ., Garabiag, K. ., Santos, M. T. ., Atienza, C. ., Garay, A. ., & Fernandez, R. . (2008). Financial access and inclusion in agricultural value chain. In *Asia-Pacific Rural and Agricultural Credit Association (APRACA) FinPower publications*.

Parvadavardini, S., & Nagarajan, V. (2015). A study on the agricultural value chain financing in India. *Agricultural Economics (AGRICECON)*, *61*(1), 31–38.

Passel, S. Van, Huylenbroeck, G. Van, Lauwers, L., & Mathijs, E. (2009). Sustainable value assessment of farms using frontier efficiency benchmarks. *Journal of Environmental Management*, *90*(10), 3057–3069.

Pearce, D. (2003). Buyer and Supplier Credit to Farmers: Do Donors have a Role to Play? *Paving the Way Forward for Rural Finance: An International Conference on Best Practices*.

Petrick, M. (2004). Farm investment, credit rationing, and governmentally promoted credit access in Poland: A cross-sectional analysis. *Food Policy*, *29*(3), 275–294. https://doi.org/10.1016/j.foodpol.2004.05.002

Pham, T. T. T., & Lensink, R. (2007). Lending policies of informal , formal and semiformal lenders. *The Economics of Transition*, *15*(2), 181–209.

Pingali, P., Khwaja, Y., & Meijer, M. (2005). The Future of Small Farms The Future of Small Farms. In R. Pandya-Lorch, P. Hazell, C. Poulton, & A. Dorward (Eds.), *The Future of Small Farms*.

Porter, M. E. (2008). *Competitive advantage-Creating and Sustaining Superior Performance*. The Free Press.

Putro, P. A. W., Purwaningsih, E. K., Sensuse, D. I., & Suryono, R. R. (2022). Model and implementation of rice supply chain management: A literature review. *Procedia Computer Science*, 197, 453-460. https://doi.org/10.1016/j.procs.2021.12.161

Rahman, S. ur, Hussain, A., & Taqi, M. (2014). Impact of Agricultural Credit on Agricultural Productivity In Pakistan : An Empirical Analysis ISSN : 2278-6236. *International Journal of Advanced Research in Management and Social Sciences*, *3*(4), 125–139. https://www.academia.edu/7745629/Impact_of_Agricultural_Credit_on_Agricultural_Pr

oductivity_in_Pakistan_An_Empirical_Analysis

Rapisarda, P., Rizzo, M., & Scuderi, A. (2015). Analysis of a direct selling network for agrifood products. *Italian Journal of Food Science*, *27*(1), 109–117. https://doi.org/10.14674/1120-1770/ijfs.v81

Reyes, A., Lensink, R., Kuyvenhoven, A., & Moll, H. (2012). Impact of Access to Credit on Farm Productivity of Fruit and Vegetable Growers in Chile. *2012 Conference, August 18-24, 2012, Foz Do Iguaçu, Brazil*.

Reyes, B., Donovan, C., Bernsten, R. H., & Maredia, M. (2012). *Market participation and sale of potatoes by smallholder farmers in the central highlands of Angola : A Double Hurdle approach Market participation and sale of potatoes by smallholder farmers in the central highlands of Angola : A Double Hurdle approach* (Issue January).

Ritter, E., Barrandalla, L., Malley, Z., Ongol, M. P., Kaaya, A., Mínguez, M. del R., & de Galarreta, J. I. R. (2017). The Spirit Project : Strengthening the Capacities for Fostering Innovation Along Potato Value Chains in East Africa. *Open Agriculture*, *2*(1), 425–430.

Rosegrant, M. W., & Cline, S. A. (2003). Global Food Security : Challenges and Policies. *Science*, *302*(5652), 1917–1919. https://doi.org/10.1126/science.1092958

Rosenbaum, P. R., & Rubin, D. B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika*, *70*(1), 41–55.

Rubin, D. B. (2001). Using Propensity Scores to Help Design Observational Studies: Application to the Tobacco Litigation. *Health Services & Outcomes Research Methodology*, *2*, 169–188.

Ruete, M. (2015). Financing for Agriculture: How to boost opportunities in developing countries: *Investment in Agriculture*, Policy Brief, 3. https://www.iisd.org/sites/default/files/publications/financing-agriculture-boost-opportunities-devloping-countries.pdf

Sahn, D. E., Frausum, Y. Van, & Shively, G. (1994). Modeling the Nutritional and Distributional Effects of Taxing Export Crops. *Economic Development and Cultural Change*, *42*(4), 773–793. https://www.jstor.org/stable/1154296. Accessed: 22-07-2021

Saleem, M. A., & Jan, F. A. (2011). The Impact of Agricultural Credit on Agricultural Productivity in Dera Ismail Khan (District) Khyber Pakhtonkhawa Pakistan. *Europian Journal of Business and Management*, *3*(2), 38–44.

Samuelson, P. A. (1956). Social Indifference curves. *The Quarterly Journal of Economics*, *70*(1), 1–22.

SBP. (2014). *Value chain contract farmer financing: State Bank issues guidelines (The State Bank of Pakistan) | The Express Tribune*. State Bank of Pakistan. https://tribune.com.pk/story/769958/value-chain-contract-farmer-financing-state-bank-issues-guidelines/

Sebatta, C., Mugisha, J., Katungi, E., Kashaaru, A., & Kyomugisha, H. (2014). Smallholder Farmers' Decision and Level of Participation in the Potato Market in Uganda. *Modern Economy*, *05*(08), 895–906. https://doi.org/10.4236/me.2014.58082

Sebatta, C., Wamulume, M., & Mwansakilwa, C. (2014). Determinants of Smallholder Farmers' Access to Agricultural Finance in Zambia. *Journal of Agricultural Science*, *6*(11), 63. https://doi.org/10.5539/jas.v6n11p63

Setboonsarng, S., Leung, P., & Stefan, A. (2008). *Rice Contract Farming in Lao PDR: Moving from Subsistence to Commercial Agriculture*. www.adbi.org

Shepherd, A. W. (2004). *Financing agricultural marketing- The asian experience*. http://www.ruralfinanceandinvestment.org/sites/default/files/1153747507539_Back_7_3__Trader_Fin_in_Asia_FAO.pdf

Shiferaw, B., Obare, G., & Muricho, G. (2008). Rural market imperfections and the role of institutions in collective action to improve markets for the poor. *Natural Resources Forum*, *32*(1), 25–38.

Singh, D. K. (2018). Determinants of dairy farmers' choice of marketing channels in Bihar, India. *Agricultural Economics Research Review*, *31*(1), 149. https://doi.org/10.5958/0974-0279.2018.00015.0

Singh, I., Squire, L., & Strauss, J. (Eds.). (1986). *Agricultural household models: Extensions, applications, and policy*. Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/621291468739297175/Agricultural-household-models-extensions-applications-and-policy

Smith, J., Todd, P., Becker, S., Black, D., Edin, P.-A., Frölich, M., Ham, J., LaLonde, R., Lechner, M., Lemieux, T., & Plesca, M. (2005). Does Matching Overcome Lalonde's Critique of Nonexperimental Estimators? *Journal of Economics*, *125*(1–2), 305–353.

Sori, O., & Aman, M. (2017). *Factors Affecting Market Outlet Choice of Groundnut Producers in Digga District of Oromia State , Ethiopia*. *8*(17), 61–68.

Stiglitz, J. E., Weiss, A., Reyes, A., Lensink, R., Kuyvenhoven, A., & Moll, H. (1981). Credit Rationing in Markets with Imperfect Information. *American Economic Review*, *71*(3), 393–410.

Strauss, J., & Thomas, D. (1995). *Empirical modeling of household and family decisions.* Handbook of development economics, *3*, 1883-2023. https://doi.org/10.1016/S1573-4471(05)80006-3

Strohm, K., & Hoeffler, H. (2006). *Contract Farming in Kenya: Theory, Evidence from selected value chains, and implications for Development cooperation*.

Taiy, R. J., Onyango, C., Nkurumwa, A., Ngetich, K., Birech, R., & Ooro, P. (2016). Potato Value Chain Analysis in Mauche Ward of Njoro Sub-County , Kenya. *International Journal of Horticulture and Social Sciences*, *6*(5), 129–138.

Tarekegn, K., Haji, J., & Tegegne, B. (2017a). Determinants of honey producer market outlet choice in Chena District, southern Ethiopia: a multivariate probit regression analysis. *Agricultural and Food Economics*, *5*(1), 0–14. https://doi.org/10.1186/s40100-017-0090-0

Tarekegn, K., Haji, J., & Tegegne, B. (2017b). Determinants of honey producer market outlet choice in Chena District, southern Ethiopia: a multivariate probit regression analysis. *Agricultural and Food Economics*, *5*(1), 20. https://doi.org/https://doi.org/10.1186/s40100-017-0090-0

Temu, A. E. (2009). Innovations in addressing Rural Finance challenges in Africa. In *AFRACA Rural Finance Series Number 6*.

Tenge, N. G., Mutabazi, A., & Thomas, T. S. (2012). East African agriculture and climate change: A comprehensive analysis -Rwanda. *International Food Policy Research Institute*, *1*, 127–139.

Trienekens, J. H. (2011). Agricultural Value Chains in Developing Countries A Framework for Analysis. *International Food and Agribusiness Management Review*, *14*(2), 51–83.

Tura, E. G., & Hamo, T. K. (2019). *Determinants of Tomato Small holder Farmers Market Outlet Choices in West Determinants of Tomato Smallholder Farmers Market Outlet Choices in West Shewa , Ethiopia*. *June 2018*.

Uwamahoro, F., Berlin, A., Bucagu, C., Bylund, H., & Yuen, J. (2018). Potato bacterial wilt in Rwanda : occurrence , risk factors , farmers ' knowledge and attitudes. *Food Security*, *10*(5), 1221–1235.

Vogel, C., Mathé, S., Geitzenauer, M., Ndah, H. T., Sieber, S., Bonatti, M., & Lana, M. (2020). Stakeholders' perceptions on sustainability transition pathways of the cocoa value chain towards improved livelihood of small-scale farming households in Cameroon. *International Journal of Agricultural Sustainability*, *1*8(1), 55-

69. https://doi.org/10.1080/14735903.2019.1696156

WB. (2008). *The Growth Report: Strategies for Sustained Growth and Inclusive Development*. https://doi.org/10.1596/978-0-8213-7491-7

W.B.(2022). W*ord development indicators.* Retreived November 14, 2022, from https://databank.worldbank.org/source/world-development-indicators#

WB. (2017). *Rwanda Economic Update, August 2017:Sustaining Growth by Building on Emerging Export Opportunities*. World Bank, Kigali. https://openknowledge.worldbank.org/handle/10986/28111

Wiggins, S., & Keats, S. (2013). Leaping & Learning: Linking smallholders to markets in Africa. In *Agriculture for impact. Imperial College, London* (Issue May).

Winn, M., Miller, C., & Gegenbauer, I. (2009). The use of Structured Finance instruments in agriculture in Eastern Europe and Central Asia Ivana Gegenbauer. In *Agricultural Management, Marketing and Finance Service (AGSF)*. http://www.fao.org/3/ap294e/ap294e.pdf

Wooldridge, J. M. (2005). *Instrumental estimation of the average treatment effect in the correlated random coefficient model*. https://doi.org/doi:10.1920/wp.cem.2004.0304

Xaba, B. G., & Masuku, M. B. (2012). Factors Affecting the Choice of Marketing Channel by Vegetable Farmers in Swaziland. *Sustainable Agriculture Research*, *2*(1), 112. https://doi.org/10.5539/sar.v2n1p112

APPENDECES

APPENDIX A: INTRODUCTORY LETTER AND SURVEY QUESTIONNAIRES

Target Audience:

(i) Potato individual farmers, potato cooperatives, potato processors, potato traders and potato consumers

(ii) Staff in agricultural finance and lending institutions (Commercial banks, MFI's and credit cooperatives, input traders) offering credit to potato farmers

Dear respondents,

My name is **PATRICE MUGENZI,** I am doing PhD studies in agribusiness Management at Egerton University-Njoro Campus/Nakuru /Kenya. I am carrying out research on **"Effects of Agricultural Value Chain Financing on Potato Productivity and Market Access on Farm Household's Livelihood in Musanze and Nyabihu Districts, Rwanda"**as a partial fulfilment of the requirements for the Degree of Doctor of Philosophy in agribusiness Management. This is part of an on-going initiative to promote farming activities and participating in problem resolving to increase the welfare of farmers. You are selected because you are a key player in the potato value chain. I am therefore requesting you to be free and openly participate in this survey. I assure you that the information collected will be kept with utmost confidentiality, anonymity and privately for this academic research.

Thank you in advance for your participation

PATRICE MUGENZI

Phone +250788856810

Email: patem03@gmail.com

4.1: SURVEY QUESTIONNAIRE TO FARM HOUSEHOLDS

Section A: Questionnaire identification			**CODE**
A.1	Questionnaire number		
A.2	Date of interview		
A.3	Name of enumerator's		
A.4	Telephone number		
Section B: Background Information of the Respondent			
B.1	Name of respondent/Head of family		
B.2	Telephone number		
B.3	District		
B.4	Sector		
B.5	Cell		
B.6	Relationship of the respondent to Household head	0=Husband 1=Wife 2=Son/daughter 3=relative 4= other (specify)	|_____|
B.7	Gender	0=Female 1= Male	|_____|
B.8	Marital status	0=Single 1= Married 2= Widowed 3= Separated 4= Divorced	|_____|
B.9	Age (Years)	0=Less than 20 1= Between 21-30 2=Between 31-40 3=Between 41-50 4= above 50	|_____|
B.10	What is the highest level of formal education have you attained	0=no formal education 1=primary level 2=secondary level 3= tertiary level (A1&A0) 4= Master &PhD 5= other (specify)	
B.11	Household size	0=Between 1-3 1=Between 4-6 2=Between 7-9 3= Between 9-11 4= More than 11	|_____|
			|_____|
B.12	What is the main economic occupation of the household head?	0=Agriculture and Livestock 1= Agriculture and Employed (public or	|_____|

		Private) 2= Agriculture and Pensions/Remittances 3= Agriculture and Handcraft 4= Agriculture and Running a shop or commerce 5= Other (specify)	

B.13	Assets owned (tick any types of assets owned by the household)	1=Yes 0= No
	Land	|_____|
	Buildings	|_____|
	Livestock	|_____|
	Transport means (Bicycle, Moto, Vehicle...)	|_____|
	Households' equipment	|_____|
B.14	How many years of farming experience is the household practiced potato farming (number of years)?	
	0= Below 1	|_____|
	1= Between 1-5	
	2= Between 6-10	
	3= Between 11-15	
	4=Above 15	
	0= Below 1	
B.15	Have you participated or been trained in potato production workshop or training?	1= Yes 0= No
		|_____|
B.16	What was the domain of your training? ……..	
B.17	Are you member of a farming organization?	1= Yes 0= No
		|_____|
B.18	If "yes", in what type of farmer organization do you belong to? (Multiple answers	1=Yes

	possible)	0= No
	Producer organization	|_____|
	Saving and Credit organization	|_____|
	Social welfare organization	|_____|
	Marketing organization	|_____|
	Transport	|_____|
	Other (specify)	
B.19	What benefits do you derive from being a member of these organizations? (Multiple answers possible)	
	0 = Experience and information sharing	|_____|
	1 = Social support (in case of death or parties)	
	2 = Marketing and Networking	
	3 = Access to seeds and fertilizers	
	4 = Accessing credit	
B.20	Which materials were used to build the main household's house?	
	0= Iron sheet roof- bricks wall- cement floor	
	1= Tile roof – bricks wall -cement floor	
	2=Iron sheet roof- mud wall-cement floor	
	3= Tile roof - mud wall-cement floor	
	4=Iron sheet roof-mud wall-mud floor	|_____|
	5= Tile roof -mud wall-mud floor	
	6=Grass thatched roof- tree wall-mud floor	
	7= others (specify)	
B.21	What is the total size of farming owned by the household in last three years 2017-2019 (owned and rented in hectares)?	
	0= Less than 0.5	
	1=Between 0.5 – 1	|_____|
	2=Between 1-2	
	3=Between 2-5	
	4=More than 5	

B.22	What is the total size for potato production owned by the household in last three years 2017-2019 (owned and rented in hectares)?	
	0= Less than 0.5	
	1=Between 0.5 – 1	
	2=Between 1-2	
	3=Between 2-5	|_____|
	4=More than 5	
B.23	How do you plough your farm	
	0= Hoe	
	1= Oxen	
	2= Tractors	|_____|
	3=Others	

B.24	What are the major reasons for venturing into potato farming? (tick any of following reasons)	1=Yes 0= No
	Household food needs	|_____|
	Agribusiness	|_____|
	Commercial	|_____|
	Regional crop -Hobbies	|_____|
	Other specify	|_____|
B.25	What are the major sources of household income? (tick any source of income)	1=Yes 0= No
	Agriculture and Livestock	|_____|
	Salary	|_____|
	Pensions allowances	|_____|
	Handcraft	|_____|
	Running a shop	|_____|
	Other specify	|_____|
B.26	How much is your household's total annual income	

B.27	How much do you earn from potato farming (Yearly)?	|_____|
B.28	How much is your household's yearly expenditures? (in Frw)	|_____|

Section C: Sources of finances for Potato value chain activities		**Responses**	**CODE**
C.1	Did you use credit to finance your potato activities in last three years (2017-2019?	1=Yes 0= No	|_____|

N.B: If your answer to question C.1 is "Yes" proceeds with C.2, if "No" skip to question D.1

C.2 Within the last 3 years, have you borrowed from any of these lenders?

If yes, please fill-in the following this table (type of borrowing, times of borrowing, amount borrowed in Frw, amount obtained in Frw, amount in Frw used in potato production, preferred sources of finance)

	Types of lenders for potato activities	Borrowed 1=Yes 0=No	Kind (0)/ Cash (1)	How many times have borrowed from the lender	How much have you borrowed (Frw) (**Code B**)	What was the annual interest rate?(**Code C**)	What was the repayment period	How much money have you obtained	How much money have you used in	What was the mode of	How would you rate the lending terms/ conditions
	Inputs suppliers (seeds)	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Inputs suppliers (fertilizers and Pesticides)	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Processors	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|

	Wholesaler	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Commercial banks	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	MFI's (SACCO's)	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Cooperative Societies	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Government subsidies (support)	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	NGO's project	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Rotating savings and credit associations (ROSCA's)	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Friends or relatives	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|
	Other sources (specify)	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|	|_____|

Key A: 0=once 1=twice 2= three times 3= four times 4=more than 4 times

Key B: 0= less than 100000, 1=100001-200000 2= 200001-300000, 3=400001- 500000, 4= more than 500000

Key C: 0= 2-5% per annum, 1= 5-10% annum 2= 10-15% annum 3= 15-20% annum 4= more than 20 %

Key D: 0= 1-4months 1=4-8 months, 2= 8-12 months, 3=1-2 years, 4= over 2 years

Key E: 0= less than 100000, 1=100001-200000 2= 200001-300000, 3=400001- 500000, 4= more than 500000

Key F: 0= less than 100000, 1=100001-200000 2= 200001-300000, 3=400001- 500000, 4= more than 500000

Key G: 0= Weekly 1= Monthly 2= Termly (4) 3=Semester (6) 4= annually (12)

Key H: 0= Very Poor; 1= Poor; 2=Fair; 3=Good; 4= Very good

C.3	**What are the requirements to access the loan from the above sources of finance?**												
	Types of lenders for potato activities	Collateral (assets	Farmer's repayment	Profitability of farm (Farmer's	Quota amount on Saving	Government Condition	Loan size	Farmer management	Farm size	Agreement with Spouse	Member of any registered	Volume of potato produce	Existence of sales contracts.
	Inputs suppliers (seeds)	_____	_____	_____	_____	___	___	_____	___	___	____	____	____
	Inputs suppliers (fertilizers and Pesticides)	_____	_____	_____	_____	___	___	_____	___	___	____	____	____
	Processors	_____	_____	_____	_____	___	___	_____	___	___	____	____	____
	Wholesaler	_____	_____	_____	_____	___	___	_____	___	___	____	____	____
	Commercial banks	_____	_____	_____	_____	___	___	_____	___	___	____	_____	____
	MFI's (SACCO's)	_____	_____	_____	_____	___	___	_____	___	___	____	_____	____
	Cooperative Societies	_____	_____	_____	_____	___	___	_____	___	___	____	_____	____

C.3	What are the requirements to access the loan from the above sources of finance?												
	Types of lenders for potato activities	Collateral (assets	Farmer's repayment	Profitability of farm (Farmer's	Quota amount on Saving	Government Condition	Loan size	Farmer management	Farm size	Agreement with Spouse	Member of any registered	Volume of potato produce	Existence of sales contracts.
	Government subsidies (support)	|_____|	|_____|	|_____|	|_____|	|___|	|___|	|_____|	|___|	|___|	|_____|	|_____|	|_____|
	NGO's project	|_____|	|_____|	|_____|	|_____|	|___|	|___|	|_____|	|___|	|___|	|_____|	|_____|	|_____|
	Rotating savings and credit associations (ROSCA's)	|_____|	|_____|	|_____|	|_____|	|___|	|___|	|_____|	|___|	|___|	|_____|	|_____|	|_____|
	Friends or relatives	|_____|	|_____|	|_____|	|_____|	|___|	|___|	|_____|	|___|	|___|	|_____|	|___|	|___|

Key: Rating from 0 to 4

0=not important; 1= slightly important; 2=important; 3=fairly important; 4= very important

C.4.	**What was the main use of the credit in potato farming activities (tick any possibilities)?**	1=Yes 0= No	**CODE (Rank importance)**
	Buying land		|_____|
	Buying improved seeds		|_____|
	Buying fertilizers and pesticides		|_____|
	Hiring farm workers		|_____|
	Farm rental		|_____|
	Buying or Hiring agriculture machineries		|_____|
	Harvesting activities		|_____|
	Debt repayment		|_____|
	Paying taxes		|_____|
	Acquiring potato market information		|_____|
	Negotiating potato selling price		|_____|
	Transporting potato to market		|_____|
	Opening a supermarket		|_____|

Key: Rating from 0 to 4 (0=not important; 1= slightly important; 2=important; 3=fairly important; 4= very important)

C.5.	**Have you already paid the loan received from agricultural finance and financial institutions**	1=Yes 0= No	|_____|
C.6	**If yes, list down the important ways you have used to pay your loan**		
C.7	**If no list down the important problems faced to pay back the loan?**		

Section D: Constraints hindering smallholder farmers to access agricultural finances along the potato value chain		
D.1	**If you answered to question C.1 is no, what could have been the major constraints faced in accessing agricultural credit along the potato value chain? (Tick any possible responses based on the important constraints)**	**CODE1=Yes 0=No**
	Afraid to borrow	|____|
	Uncertainty of payment	|____|
	Poor skills in project budgeting	|____|
	Inadequate information on the availability of loan for cultivation	|____|
	Loan provided for cultivation does not cover the farmers' needs	|____|
	Financial illiteracy (limited skills and knowledge on how lending institutions operate)	|____|
	Interest rates and other loan charges are too high for an agricultural loan	|____|
	Inadequate savings	|____|
	Short repayment period for the loan provided for agriculture	|____|
	Many documents required to process the loan	|____|
	Inadequate collaterals	|____|
	Long distance (Location) from farm to FI's offices	|____|
	Long application processes for cultivation loan compared to other loan	|____|
	Corruption or bribery by credit officers	|____|
	Unpredictable production (weather changes)	|____|
	Others (specify)	

D.2	**What do you think should agricultural finance and lending institutions do to encourage farmers borrow from them? (Rank from the most important to the least important)**	**CODE** Ranks 1=Yes 0= No
	Set up rural branches/ agents to bring service near to farmers	|_____|
	Educate farmers on need and benefits of agricultural loans	|_____|
	Develop financial products that match farmers' needs	|_____|
	Reduce the interest rate to agricultural loans	|_____|
	Provide grace period for agricultural loans	|_____|
	Develop insurance schemes for agricultural practices	|_____|
	Others (specify)	|_____|

Section E: Effect of Agricultural finance on potato productivity (yields) and potato production			**CODE**
E.1	Does access to agricultural loan have an impact on the quality and quantity of potato produced?	1=Yes 0= No	|_____|
E.2	If yes, on what has agricultural loan contributed more to improve productivity? (Tick any possible answer according to its contribution)		
	Buying & lease new land		|_____|
	Easy access to inputs (fertilizer, pesticides, improve seeds)		|_____|
	Access to improved seeds		|_____|
	Improved efficiency in use of inputs (reduce the use of inputs)		|_____|
	Access to and efficient use of modern agri. machineries Materials (tractor, mechanization…)		|_____|
	Hiring competent labours		|_____|

	Access agricultural Products market	|_____|
	Access to farming skills (trainings, seminars…)	|_____|
	Increase off farm activities	|_____|
	Increase in business income	|_____|
	Increase Livestock assets	|_____|
	Access to extension training/services	|_____|

Key: Rating from 0 to 4 (0=not important; 1= slightly important; 2=important; 3=fairly important; 4= very important)

E.3	Have you ever been visited by extension officer during you potato production activities?	1=Yes 0= No	|_____|
E.4	If "yes" how often have you been visited?	0=Once a month 1= Two times a month 2=Three times a month 3=Once in six months 4= Never visited	|_____|
E.5	If "yes" which message related to increase your potato production have you gained from the extension officer? …… …… ……		
E.6	If "no", how do you get the knowledge of how to increase your production? …… …… ……		

Section F: Effect of Agricultural finance to increase the gross margins/ price to potato farmers in Rwanda									
F.1.	How much have invested in Potato production (productivity before and after accessing agricultural loan)								
	Element of production	**Before agricultural loan**				**After agricultural loan**			
		2017	2018	2019	Total average	2017	2018	2019	Total average
	Land rent								
	Land preparation/ploughing								
	Potato seeds								
	Fertilizers (organic and inorganic)								
	Harrowing								
	Planting								
	Pesticides								
	Fungicides								
	Irrigation								
	Weeding								
	Harvesting								
	Transportation								
	Storage								
	Loan cost								
	Hired labour								
	Family labour								
	Extension services								
	Other costs								
	Total Variable costs								

F.2	**How many kg have you harvested in last 3 years? 2017-2019? How much was the price per kg?**						
	Before agricultural loan				**After agricultural loan**		
	Period of	**Total production (kg)**	**Price (FRW/kg)**	**Annual revenue**	**Total producti**	**Price (FRW/kg)**	**Annual revenue**
	Year 2017						
	Year 2018						
	Year 2019						
	Total average						
F.3	**What is the household income before and after accessing and using agricultural loan (FRW)? Tick any possible answer according to your income) (Tick V)**						
	Less than 100000		|_____|		|_____|
	100001-200000		|_____|		|_____|
	200001-300000		|_____|		|_____|
	300001-400000		|_____|		|_____|
	400001-500000		|_____|		|_____|
	More than 500000		|_____|		|_____|

F.4. What are the main challenges do you have to expand your potato activities? (Rank them according to their position in potato production)		Rank (Key)
	Poor access to seeds	|_____|
	Poor access to fertilisers	|_____|
	Inadequate capital	|_____|
	Poor access to potato market	|_____|
	Any other challenges (specify)	|_____|
	Any other (specify)……	|_____|

Key: Rating from 0 to 4 (0=not important; 1= slightly important; 2=important; 3=fairly important; 4= very important)

F.5	**Potato varieties grown by farmers** (Mention any possible answer according to preferences and productivity)	

Section G: Evaluate the factors that influence potato farmers' to access to potato markets			RESPONSE
G.1	Do you sell any potato production to market?	1=Yes 0= No	|_____|
G.2	If Yes, who is responsible for selling the potato produce in your family	1= Husband 2= Wife 3= Both Husband and Wife 4= Other household member	|_____|
G.3	Do you have access to market information	1=Yes 0= No	|_____|
G.4	Do you make any investment to search for market information?	1=Yes 0= No	|_____|
G.5	If Yes, what it is the main source of market information?	0= Local traders 1= Government announcement 2= Media 3= Brokers/ middlemen 4=Cooperatives 5= Any Others specify..	|_____|

G.6	**Where do you sell potato production?** (Major market outlets)								
		Wholesalers	Processors	Brokers	Cooperatives	Collection centres	Retailers	Consumers	Any other (specify)
	1=Yes	___	___	___	___	___	___	___	___
	0= No	___	___	___	___	___	___	___	___

G.7 Major market outlets for potato production (Provide the following information in table below)		Total Quantity of Potato harvested	Quantity of Potato kept by the household for family	Quantity Sold (kg)	Selling price per kg(FRW	Total revenue (Qty*Selling price)	Time required Hrs	Distance covered from the farm to nearest market (Km)	Distribution /transportation cost
	Wholesalers								
	Processors								
	Brokers								
	Cooperatives								
	Collection centres								
	Retailers								
	Consumers								
	Any other (specify)								

G.8	What are important factors that push you to choose one of the above market outlets?																		
	Major Market outlets	**Factors of decision choices** (Rate factors according to its importance)																	
		Age of household head	Gender of the household head	Size of Farmer's	Level of Education of	Potato Farming experiences	Access to Credit	Farmer's income (own or borrowed)	Government intervention (restriction to sell at particular	Volume of potato produce in stock to	Better Selling price (FRW/kg)	Time to market Hrs.	Distance to market (km)	Distribution /transportation cost	Seed varieties (table or processing)	Membership of registered cooperative	Trust between Farmer	Access to Market information	Frequent contact with	Training on market	Existence of sales
	Wholesalers	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|__|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|
	Processors	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|__|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|
	Brokers	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|_ _|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|
	Cooperatives	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|__|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|
	Collection centres	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|__|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|
	Retailers	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|__|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|
	Consumers	|__|	|__|	|_|	|_|	|_|	|__|	|__|	|__|	|__|	|__|	|_|	|__|	|__|	|__|	|_|	|_|	|_|	|_|	|_|

Key:: 0= No 1= Yes

G.9	How do you transport your potato production to the market in last three years (2017-2019)?	0=By head 1=By bicycle 2= By own Vehicle 3=By hired vehicle 4=Any other (specify)	|_____|
G.10	Do you participate in fixation of selling prices of the potato produce		|_____|
G.11	Who fixes the price of the potato produce?		
	Government officers	1= Yes 0= No	|_____|
	Wholesalers	1= Yes 0= No	|_____|
	Processors	1= Yes 0= No	|_____|
	Brokers/ Middlemen	1= Yes 0= No	|_____|
	Cooperatives	1= Yes 0= No	|_____|
	Collection centres	1= Yes 0= No	|_____|
	Retailers	1= Yes 0= No	|_____|

	Consumers	1= Yes 0= No	|_____|
	Any other…… …… ……		

G.12	**What are the major factors that affect potato farmers in accessing to market?** (Tick any possible factors according to their importance	**CODE (Rank importance)**
	Age of household head	|_____|
	Gender of the household head	|_____|
	Size of Farmer's household	|_____|
	Level of Education of household head	|_____|
	Farming experiences of household head	|_____|
	Volume of potato produce in stock to supply (quantities in Kg)	|_____|
	Farmer's income (own or borrowed)	|_____|
	Access to credit	|_____|
	Better Selling price FRW/kg	|_____|
	Good infrastructure (roads)	|_____|
	Potato Market organization	|_____|
	Government intervention (Poor clear Policy= restriction to sell at particular market)	|_____|
	Time to market Hrs.	|_____|
	Distance to market (Km)	|_____|
	Seed varieties (table or processing)	|_____|
	Membership of registered cooperative /association	|_____|
	Trust between Farmer and buyer	|_____|
	Access to Market information	|_____|
	Frequent contact with Middlemen	|_____|
	Training on market choice	|_____|

Key 0= No **1= Yes**

G.13	**List down major constraints faced by farmers to access to potato market? (Start with very important constraints to the least important)**	**CODE (**1=Yes 0= No**)**
	Inadequate market information	|_____|
	High transportation cost	|_____|
	Long distance to market	|_____|
	Lower investment	|_____|
	Inappropriate technology	|_____|
	Poor potato storage facilities	|_____|
	Inadequate and effective selling policies	|_____|
	Low farmers' power to potato market	|_____|
	Low selling price	|_____|
	High price fluctuation	|_____|
	High post-harvest and storage handling losses (perishability)	|_____|
	Delaying Payments	|_____|

G.13	**List down some remedies to constraints faced by farmers in selling potato production? (Start with very important constraints to the least important)**	
	…….	
	…….	
	…….	
	…….	
Section H: Effects of agricultural finance on the livelihood farm households		**CODE**

H.1	Did use of agricultural loan in potato improve the wellbeing of your household in relation to the rest of the farmers after access/use of agricultural loan?	1=Yes 0= No	|_____|
H.2	If "Yes", what indicators do you use to rank improvement of your household wellbeing after access/use of agricultural loan compared to the rest of farmers?		1=Yes 0= No
	Increase the abilities to feed the family		|_____|
	Increase the abilities to pay school fees,		|_____|
	Increase the abilities to pay health care fees		|_____|
	Spending time with friends and family (recreation)		|_____|
	Being among opinion leaders for decisions making committees (At village level, cell level, sector level, district…)		|_____|
	Provide employment to other people around		|_____|
	Building modern/new house (specify the materials)		|_____|
	Buying new household furniture (Sofa, fridge…)		|_____|
	Buying livestock (cow, sheep,. goat, pig)		|_____|
	Buying transport assets (bicycle or motorbike or car…(specify)		|_____|
	Improve the physical appearance of my family (clothing, clear skin)		|_____|
	Access to telecommunications and media devices (Radio, TV, Mobile phone,..)		|_____|
	Access to water and Electricity services at home		|_____|
	Buying or extending the land		|_____|
	Others (specify)……..……..		

Thank you for the information given

A. 2: SURVEY QUESTIONNAIRE TO AGRICULTURAL FINANCE AND LENDING INSTITUTIONS

Section A: Background Information of the Respondent		
A.1	Name of Institution	
A.2	Name of respondent	
A.3	Function of respondent	
A.4	Telephone number	

Section B: Types of financing products offered to farmers		
B1	Do you provide agricultural loan to smallholder potato farmers?	0= No |_____| 1= Yes |_____|
B2	**If "Yes", how do you provide of agricultural loan do to farmers?**	0= No |_____| 1= Yes |_____|
	Provided to input traders	|_____|
	Provided to individual farmer	|_____|
	Provided to farmer cooperative organizations	|_____|
	Provided to processors	|_____|
	Provided to wholesalers	|_____|
B3	**If "Yes", what type of agricultural loan do you provide to farmers?**	
	Provide cash used in potato production	|_____|
	Provide Fertilizers used in potato production	|_____|
	Provide potato improved seeds	|_____|
	Other type of loan	
B4	**If "Yes", how much have you disbursed to farmers in last 3 years (2018-2020)**	

	Year	Disbursed	Recovered	Not recovered
	2017			
	2018			
	2019			

B.5	What are the main challenges do you face in lending to smallholder potato farmers?	CODE 0= No 1= Yes
	Low profitability on investment in agriculture	|_____|
	Limited loans available to agricultural activities	|_____|
	Low skills and knowledge by farmers in use of loans	|_____|
	Asymmetric information from farmers side	|_____|
	High level of financial risks (Unpaid loans)	|_____|
	Uncontrolled risks in agriculture sector (natural hazards, unpredicted weather …)	|_____|
	Unpredicted (fluctuating) potato production	|_____|
	Unpredicted (fluctuating) potato market price	|_____|
	High transaction costs	|_____|
	Poor infrastructure to reach farmers	|_____|
	Inadequate collaterals	|_____|

B.5	What are your suggestions to easily extend credit services to potato farmers (list down any suggestions)

Thank you for the information given

A. 3: SURVEY QUESTIONNAIRE TO POTATO TRADERS AND PROCESSORS

Section A: Questionnaire identification		
A.1	Questionnaire number	
A.2	Date of interview	
A.3	Name of enumerator's	
Section B: Background Information of the Respondent		
B.1	Name of Institution	
B.2	Name of respondent	
B.3	Function of respondent	
B.4	Telephone number	
B.5	District	
B.6	Sector	
B.7	Cell	

Section C: Production and marketing potato products (Tick any of these products)		**CODE (**1=Yes 0= No**)**
C.1	**What types of potato products do you produce**	
	French fries	|_____|
	Crips	|_____|
	Ware potatoes (Cleaned)	|_____|
	Ware potatoes (not cleaned)	|_____|
	Potato seeds	|_____|
	Others (specify)…….	
CODE	**What is the important lending institution that finances your activities?**	**CODE (**1=Yes 0= No**)**
C.2	Own financing	|_____|
	Family	|_____|

	Commercial banks (Give the name of the Bank)	|_____|
	MFI's (SACCO's)	|_____|
	Cooperative Societies (Name of the cooperative)	|_____|
	Rotating savings and credit associations (ROSCA's)	|_____|
	Government subsidies (support)	|_____|
	NGO's project	|_____|
	Any others (specify)	|_____|

C.3	**Where do you buy the Irish potato (raw materials) used in your factory?**	**CODE (**1=Yes 0= No**)**
	Individual Farmers	|_____|
	Farmer cooperatives	|_____|
	Collection centres	|_____|
	Local markets	|_____|
	Imports from neighbour countries (Uganda, DRC, Tanzania, Burundi)	|_____|
	Others (specify)…….	

C.4	Do you have any policy of financing potato value chain?	1= Yes 2= No	|_____|
C.5	**If "Yes", how do you participate in financing the potato value chain?**		**CODE (**1=Yes 0= No**)**
	Providing Inputs (fertilisers, seeds) to farmers		|_____|
	Contract of buying farmers' produce		|_____|
	Direct Financial supports to farmers		|_____|

	Direct Financial supports to farmers' organizations/cooperatives	|_____|
	Guarantor to the Bank	|_____|
	Any other (please specify) …… …… …	

C.6	**If "No", why? (Give any reasons)** …… …… …… …….	

C. 7	Over the last 12 months, what quantity of potatoes did you use in your business/factory? (fill this table for Potato demanded and potato supplied)					
	Source of potatoes	**Quantity demanded**			**Quantity supplied**	
		Unit cost (Frw/kg)	Total demanded (Kg)	Total costs (Frw)	Total sales (Kg)	Unit selling price(Frw/kg)	Total revenue (Frw)
	Individual Farmers						
	Farmers 'organizations or cooperatives						
	Collection centres						
	Local markets						
	Imports from neighbour						

	countries (Uganda, DRC, Tanzania, Burundi)				
	Other Suppliers (specify)				

C.8	What are **the problems do Traders and processors** face in potato marketing and potato processing production?	
	Potato marketing?	**Potato processing production**
	……	……
	……	……
	……	……
	……	……
	……	……
	…….	…….

C.9	What are **your suggestions for farmers** to increase production and access potato markets?
Potato productivity	**Access potato market (marketing)**
……	……
……	……
……	……
……	……..
……	…….
…….	…….

Thank you for the information given

APPENDIX B: PUBLICATIONS RELATED TO THE STUDY

B.1. What Constrains Smallholder Farmers Decisions to Participate and Use Agricultural Value Chain Financing in Rwanda? The Case of Smallholder Potato Farmers in Musanze and Nyabihu Districts

International Journal of Trend in Scientific Research and Development (IJTSRD)
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What Constrains Smallholder Farmers Decisions to Participate and use Agricultural Value Chain Financing in Rwanda? The Case of Smallholder Potato Farmers in Musanze and Nyabihu Districts

Patrice Mugenzi [1], George Owour [2], Hillary K. Bett [3]

[1]PhD Scholar Faculty of Agriculture, [2]Associate Professor,
[1,2,3]Department of Agricultural Economics and Agribusiness Management, Egerton University, Njoro, Kenya

ABSTRACT

Smallholder farmers contribute more to food security and poverty reduction in Rwanda. However, lack of agricultural finance is one of numerous challenges they face for improving productivity and increasing income along the value chain. The objectives of this paper were to determine the factors influencing the farmers' decision to participate and use agricultural value chain financing in Rwanda and to analyse the constraints hindering smallholder farmers' decision to participate and use agricultural value chain financing in Rwanda. Cross-sectional data were collected from a random sample of 585 smallholder potato farmers in Musanze and Nyabihu Districts. Results of probit model revealed that sex, age, marital status, education, farming experience, membership to farming associations, household income and distance to market significantly influence the farmers' decision to participate and use of agricultural value chain financing. The study also found that financing agricultural activities remain a key challenge for smallholder potato farmers. Fear of borrowing, lack of financial literacy, lack of skills in budgeting and unexpected production, interest rate and others loans charges, lack of collaterals, short repayment period and lack of financial literacy have been found to be the main factors constraining potato farmers' participation and use of agricultural value chain financing. Nevertheless, potato productivity will always result from the interaction between all potato value chain actors. The study recommended the government and value chain stakeholders to formulate integrated policies that facilitate smallholder farmers to access to convenient financing products in order to improve productivity and to meet the customer demands.

KEYWORDS: *Agricultural value chain financing, smallholder potato farmers, Musanze and Nyabihu districts, Probit model*

How to cite this paper: Patrice Mugenzi | George Owour | Hillary K. Bett "What Constrains Smallholder Farmers Decisions to Participate and use Agricultural Value Chain Financing in Rwanda? The Case of Smallholder Potato Farmers in Musanze and Nyabihu Districts" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-1, December 2020, pp.516-525, URL: www.ijtsrd.com/papers/ijtsrd38001.pdf

IJTSRD38001

1. INTRODUCTION

Statistics have shown that Rwanda is an agricultural based economy. The sector is a key component of Rwanda's fast growing economy, improvement of food security and poverty reduction of local population. It employs 80 percent of population, accounts for 32 per cent of the GDP growth, 45 per cent of Rwanda's exports earnings (RDB, 2013; NISR, 2017) and 90 per cent of country's food needs (W.B, 2013). Furthermore, facing sharply increased food demand and consumption habits driven by demographic factors, many efforts are invested in shifting from largely subsistence agriculture to market oriented agriculture (MINECOFIN, 2013). This process is driven by increased investment in response to the presence of massive market opportunities (Martey *et al*., 2012).

Potato (*Solanum tuberosum L.)* "Ibirayi" derived from "Uburayi" ("that which comes from Europe") is a new emerging crop that underpins the Rwanda's food security, nutrition, employment and socio-economic improvement of farmers (Tenge et al., 2012). It is one of the six priority crops (maize, wheat, rice, potato, cassava and beans) listed under crop intensification program (CIP) by the Ministry of Agriculture and Animal Resources (MINAGRI)(Kathiresan, 2011). Despite that Rwanda is ranked the sixth producer in Africa, the third in Sub-Saharan Africa and the second in East African community (FAOSTAT, 2017), the low productivity of 11 metric tons per hectare remains far below 30-40 metric tons per hectare attainable by research institutions (NISR, 2015). Research has shown that limited availability and accessibility to improved seeds and low access to fertilizers weaken the efforts of potato farmers to increase potato yields (Muhinyuza et al., 2012; Nshimiyimana et al., 2015). Though growing potato is entirely attractive (Ritter et al., 2017), the pace of agricultural financing remains slow and weak in Rwanda. Financial institutions are likely to operate with medium and large scale farmers, processors and traders and perceive smallholder farmers as not creditworthy, extremely risky and too difficult to provide loans (Oberholster *et al.*, 2015). This inefficiency of financial institutions to extend credit to farmers deprives the

URL: www.ijtsrd.com/papers/ijtsrd38001.pdf

B.2. Factors Influencing Smallholder Potato Farmers' Choice Decisions of Market Outlets in Musanze and Districts, Rwanda: A Multivariate Probit Model

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Factors Influencing Smallholder Potato Farmers' Choice Decisions of Market Outlets in Musanze and Nyabihu Districts, Rwanda: A Multivariate Probit Model

Patrice Mugenzi[1,2], George Owour[1], Hillary K. Bett[1]

[1]Department of Agricultural Economics and Agribusiness Management, Faculty of Agriculture, Egerton University (Njoro- Kenya), Egerton, Kenya
[2]Department of Rural Development and Agricultural Economics, School of Agricultural and Food Sciences, College of Agriculture, Animal Sciences and Veterinary Medicine (CAVM), University of Rwanda, Musanze, Rwanda

ABSTRACT

Potato (*Solanum tuberosum L.*) is an important crop that plays a major role in food security and poverty reduction to a large proportion of rural farmers in the North West than other parts of Rwanda. However, potato is a perishable product which necessitates an effective choice decision of the market outlet. This paper presents factors influencing smallholder potato farmers' choice decisions for market outlets in Rwanda. Through a multistage sampling technique, cross-sectional data were collected from 585 smallholder potato farmers in Musanze and Nyabihu Districts.Both descriptive statistical methods and econometrics methods were used for data analysis. Multivariate probit model was used to determine the factors influencing smallholder potato farmers' choice decision to sell to particular market outlets. Results showed that farming experiences, level of education of decision maker, household size, household income, household assets, access to market information and distance to market significantly influenced the smallholder potato farmers' choice decisions of selling to consumer, retailer, wholesaler, cooperative, collection centres and processors market outlets. The study recommends establishment of structured market systems to improve access to potato market information. This should be supported by agricultural financingfor improved seeds acquisition and other productive inputs to enable farmers to increase surplus potato supplied to market. Improving the farmers' education in marketing would also help them to effectively deliver potato to efficient market outlet.

KEYWORDS: *Smallholder potato farmers, Choice decision of market outlet, Multivariate probit model, Musanze and Nyabihu Districts*

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IJTSRD43632

1. BACKGROUND

Statistics have shown that Rwanda is an agricultural based economy. Its contribution of 32 percent to the GDP and 45 percent of Rwanda's exports earnings (NISR, 2017) which make the sector a critical component of the programs to reduce poverty and attain food security. Similarly to other country in SSA, the sector remains subsistence and characterised by poor infrastructure, land fragmentation, limited access to modern agricultural practices and under investment. However, following the sharply increased demand for food and consumption habits due to demographic factors, Rwanda is currently pursuing its policy of transforming and adjusting the agricultural sector from the subsistence agricultural production to market oriented agricultural production (MINECOFIN, 2013). The policy focuses on expanding the production area to improve productivity at farm level. Though, the process requires increased investment in presence of massive marketing opportunities (Martey *et al*, 2012), it can increase the income and improve the livelihoods of millions smallholder farmers. Despite the significant development of agribusiness sector and the role played by smallholder farmers in supplying the products, agricultural marketing remain a critical issue in Rwanda. Linkage between smallholder farmers with the potential markets is the persisting challenge for actors in agricultural value chains including smallholder potato farmers in Rwanda. Potato (*Solanum tuberosum L.*) is important crop introduced in Rwanda by German soldiers and Belgium missionaries in earlier 20th century(Nelson *et al*, 2016). The crop underpins the Rwanda's food security, nutrition, employment and socio-economic improvement of farmers (Tenge *et al*., 2012). Moreover, the crop contributes to poverty reduction to a large proportion of rural farmers in the North West than other parts of Rwanda. Though farmers dispose enough potentialities of increasing potato productivity many factors still limit smallholder potato farmers to access to potential markets (GIZ, 2016) and reduce their expected profitability from growing potatoes. Access to market information and other marketing facilities enable smallholder farmers to

URL: www.ijtsrd.com/papers/ijtsrd43632.pdf

APPENDIX C: PERMISSION TO CONDUCT RESEACH

C.1. NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY (NCST_RWANDA)

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY (NCST)
Grand Pension Plaza, 13th Floor, KN 2 Roundabout, Kigali
PO Box: 2285 Kigali – Rwanda
E-MAIL: info@ncst.gov.rw WEBSITE: www.ncst.gov.rw

PERMISSION TO CONDUCT RESEARCH IN RWANDA

N° NCST/482/ 134/2018

I, the undersigned, hereby grant the researcher (s) in Section I permission to conduct research in Rwanda. This permission only covers research activities related to the provided research title, during the specified period and at specified location (s) in Section II of this form.

Section I: Personal Information

1. Family Name: **Mugenzi** Other Names: **Patrice**
2. Academic Qualification (Highest degree): **MS, MA**
3. Home Institution: **Egerton University** Occupation: **PhD Student**
4. Phone Number (in Rwanda): **0788856810**
5. Email: **patem03@gmail.com**
6. Primary Research Supervisor:
   a. Names: **Prof. George Owuor**
   b. Institution: **Egerton University** Occupation: **Associate Professor**
   c. Phone Number: **+254722831634**
   d. Email: **gowuor2012@gmail.com**
7. Research Collaborators:

	Names	Institution
1		
2		
3		
4		

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Section II: Research Information

1. Research Area: **Agribusiness**
2. Research Title: **Effect of Agricultural Value Chain Financing for Potato Productivity and Market Access in Rwanda**
3. Affiliating Rwandan Institution: **UR - CAVM**
4. Rwandan Supervisor:
   a. Names: **Prof. Jean Baptiste Muhinyuza**
   b. Occupation: **Associate Professor**
   c. Phone Number: **0788436482** d. Email: **mujohnbapt25@gmail.com**
5. Fieldwork Location:

   Potato farmers organizations, potato processing factories, potato markets and financial institutions in Musanze and Nyabihu Districts, Northern and Western Provinces.

6. Research Period:
   a. From: **August 1, 2019**
   b. To: **November 30, 2019**

Section III: Other Important Notes

Section IV: Signature

This permission to conduct research in Rwanda is issued in accordance with Ministerial Instructions 003/2010 of 09/12/2010 regulating research activities in Rwanda.

Kigali, on **July 25, 2019** NCST Ref: .../NCST/2018

KALISA M. Felly

Ag. Executive Secretary

C.2. PERMISION BY MUSANZE AND NYABIHU DISTRICTS

REPUBLIC OF RWANDA

Musanze, on 29/8/2019

NORTHERN PROVINCE
MUSANZE DISTRICT
P.O.BOX 03 MUSANZE
E-mail : **musanzedistrict@musanze.gov.rw**
website: ***www.musanze.gov.rw***
Ref: *DA.HRM*

N°..1628...../07.04.03

To: Patrice MUGENZI
C/O EGERTON University

Re: Response to your letter

Dear Patrice,

Refering to your letter dated on August 13th, 2019 requesting for collecting data, in Musanze District;

I hereby inform you that you are allowed to carry out the research on **"Effects of Agricultural Value Chain Financing on Potato Productivity and Market Access in Rwanda"**.

Yours sincerely,

HABYARIMANA Jean Damascène
The Mayor of MUSANZE District

REPUBLIC OF RWANDA

Nyabihu,on 26/08/2019

N°0400/07.03.04/ANR/2019

Western Province
Nyabihu District
Website: www.nyabihu.gov.rw
E-mail:nyabihudistrict@nyabihu.gov.rw

To: Mr. Patrice MUGENZI

RE: Permission to collect research data

Dear Sir,

The reference was made to your letter received in our secretariat on August 14th, 2019 whereby you have addressed to the management of Nyabihu District your interest to collect the research data from Mukamira, Jenda, and Karago Sectors;

Referring to the existing Ministerial Instructions 003/2010 of 09/12/2010 regulating the research activities in Rwanda and other official documents presented to us;

I hereby inform you that your request has been granted, therefore you can start the collection of research data from August 22nd, 2019 to November 30th, 2019.

Best regards,

MUKANDAYISENGA Antoinette
Mayor of Nyabihu District

Cc:
-The Chairman of District Council / **NYABIHU**
-The Vice Mayor of the District (Both) / **NYABIHU**
-The executive secretary of the District / **NYABIHU**

APPENDIX D: TABLES FROM DATA ANALYSIS

D.1. Table from Probit model estimation

```
  Probit regression                                 Number of
obs     =        576

                                                  Wald chi2(15)
=     112.80

                                                  Prob > chi2
=     0.0000

Log pseudolikelihood = -332.06863                 Pseudo R2
=     0.1671


------------------------------------------------------------------

                 |               Robust

     UsAgrcredit |      Coef.   Std. Err.      z    P>|z|
[95% Conf. Interval]

-----------------+------------------------------------------------
--------------------

           SexHH |  -.4054694     .12391    -3.27   0.001    -
.6483285   -.1626104

           AgeHH |   .0143638   .0079772     1.80   0.072    -
.0012712    .0299987

                 |

          EducHH |

  Primary level  |   .3025612   .1768115     1.71   0.087
-.043983    .6491055

Secondary level  |   .7237193   .1962457     3.69   0.000
.3390848    1.108354

                 |

         marital |  -.3883081    .178277    -2.18   0.029    -
.7377247   -.0388916
```

```
       HFarmExpe |  -.0978128   .0496299    -1.97   0.049    -
.1950857   -.0005399

            HSiz |   .0536675     .03963     1.35   0.176    -
.0240058    .1313408

       lnHIncome |   .3876566   .0795031     4.88   0.000
.2318333    .5434799

    TotlandSizeH |   .0082177   .0854811     0.10   0.923    -
.1593221    .1757576

     HAssetHouse |   .5517019   .3691272     1.49   0.135    -
.1717741    1.275178

    HAssetLivest |    .157002   .1202313     1.31   0.192
-.078647     .392651

     HAssetTrans |   .1963293   .2891435     0.68   0.497    -
.3703815    .7630401

   HHMembFarmOrg |   .4443698   .1268197     3.50   0.000
.1958078    .6929319

    HTrainPotato |   .0030241   .1255791     0.02   0.981    -
.2431063    .2491545

       DistanMkt |   .0242625   .0054872     4.42   0.000
.0135079    .0350171

           _cons |  -6.584277   1.136254    -5.79   0.000    -
8.811293   -4.357261

------------------------------------------------------------------
```

D.2. Table from Multivariate probit models estimations

```
Multivariate probit (MSL, # draws = 5)             Number of
obs   =        508

                                                   Wald
chi2(96)    =     296.54

Log pseudolikelihood = -1629.7618                  Prob > chi2
=     0.0000

------------------------------------------------------------------------------
             |               Robust
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
consumer     |
        AgeHH |   .0079337   .0084572     0.94   0.348    -.0086422    .0245096
        SexHH |  -.0382919   .1337256    -0.29   0.775    -.3003892    .2238054
      marital |   .0118171     .19751     0.06   0.952    -.3752954    .3989296
       EducHH |  -.1313509   .1053578    -1.25   0.213    -.3378484    .0751466
         HSiz |  -.0191907   .0436648    -0.44   0.660    -.1047722    .0663908
    HFarmExpe |  -.1372206   .0557915    -2.46   0.014    -.2465699   -.0278712
    lnHIncome |   .2538049   .0871457     2.91   0.004     .0830026    .4246073
HHMembFarmOrg |  -.1955979   .1411723    -1.39   0.166    -.4722905    .0810946
    DistanMkt |   -.000712   .0028391    -0.25   0.802    -.0062766    .0048526
```

```
  HAssetTrans |   .4268298   .2579704     1.65   0.098    -
.0787829    .9324424

        trust |   .0697221   .1281397     0.54   0.586     -
.181427    .3208712

    AccMktInf |  -.1997315   .3324781    -0.60   0.548    -
.8513766    .4519136

 HTrainPotato |   .1404394   .1401125     1.00   0.316    -
.1341761    .4150549

VisitExtenOff |  -.0411636   .1304868    -0.32   0.752    -
.2969131    .2145858

        _cons |    -3.6537   1.236567    -2.95   0.003    -
6.077327   -1.230074

--------------+-----------------------------------------------
----------------

retailer      |

        AgeHH |   .0052261   .0079059     0.66   0.509    -
.0102692    .0207214

        SexHH |   .0543574   .1252448     0.43   0.664    -
.1911179    .2998327

      marital |  -.0496177   .1822448    -0.27   0.785     -
.406811    .3075755

       EducHH |   .2480011   .0999108     2.48   0.013
.0521795    .4438227

         HSiz |    .048655   .0405445     1.20   0.230    -
.0308108    .1281208

    HFarmExpe |   -.062045   .0508986    -1.22   0.223    -
.1618044    .0377144

    lnHIncome |   .1004675   .0722076     1.39   0.164    -
.0410569    .2419919

HHMembFarmOrg |  -.1116245    .132535    -0.84   0.400    -
.3713883    .1481392
```

```
    DistanMkt |   .0028352   .0026374     1.07   0.282     -
.002334    .0080043

  HAssetTrans |  -.0430535   .2608803    -0.17   0.869    -
.5543694    .4682624

        trust |   .1503199   .1188511     1.26   0.206     -
.082624    .3832639

    AccMktInf |   .8222792   .3754761     2.19   0.029
.0863596    1.558199

 HTrainPotato |    .056374   .1303856     0.43   0.665     -
.199177     .311925

VisitExtenOff |   .0260929   .1174854     0.22   0.824    -
.2041742      .25636

        _cons |  -2.974864   1.066381    -2.79   0.005    -
5.064932   -.8847948

--------------+-----------------------------------------------
-----------------

wholesaler    |

        AgeHH |  -.0050018   .0091031    -0.55   0.583    -
.0228436    .0128399

        SexHH |   .0462246   .1578636     0.29   0.770    -
.2631823    .3556315

      marital |   .3332451   .2423242     1.38   0.169    -
.1417016    .8081918

       EducHH |  -.2867851   .1116143    -2.57   0.010    -
.5055451   -.0680251

         HSiz |  -.1627506   .0556561    -2.92   0.003    -
.2718346   -.0536666

    HFarmExpe |   .1148164   .0571087     2.01   0.044
.0028854    .2267473

    lnHIncome |  -.2737717   .0910952    -3.01   0.003    -
.4523151   -.0952283
```

```
HHMembFarmOrg |   .0144941   .1524834     0.10   0.924    -
.2843678     .313356

    DistanMkt |  -.0191778   .0129609    -1.48   0.139    -
.0445807     .006225

  HAssetTrans |  -.1401746   .4092959    -0.34   0.732    -
.9423799    .6620307

        trust |   .2449595   .1414258     1.73   0.083      -
.03223     .522149

    AccMktInf |   .4147569   .3894615     1.06   0.287    -
.3485737    1.178087

 HTrainPotato |  -.0049078   .1540422    -0.03   0.975    -
.3068249    .2970094

VisitExtenOff |  -.2101757   .1441286    -1.46   0.145    -
.4926625    .0723112

        _cons |   2.868443   1.347696     2.13   0.033
.2270069     5.50988

--------------+-----------------------------------------------
-----------------

broker        |

        AgeHH |   .0010336   .0086449     0.12   0.905    -
.0159101    .0179773

        SexHH |   .0220081   .1346827     0.16   0.870     -
.241965    .2859813

      marital |   .0586286    .214901     0.27   0.785    -
.3625696    .4798267

       EducHH |  -.0777804   .1017769    -0.76   0.445    -
.2772595    .1216987

         HSiz |  -.0225696   .0465642    -0.48   0.628    -
.1138337    .0686945

    HFarmExpe |  -.0720618   .0536487    -1.34   0.179    -
.1772114    .0330877
```

```
    lnHIncome |   .0572514   .0804268     0.71   0.477    -
.1003823    .2148851

HHMembFarmOrg |   .0481453   .1466197     0.33   0.743    -
.2392241    .3355147

    DistanMkt |  -.0000104    .002946    -0.00   0.997    -
.0057845    .0057637

  HAssetTrans |   .0623298   .2742905     0.23   0.820    -
.4752698    .5999293

        trust |  -.1226365   .1343704    -0.91   0.361    -
.3859975    .1407246

    AccMktInf |  -.2098283   .3113875    -0.67   0.500    -
.8201365      .40048

 HTrainPotato |  -.0000766     .14523    -0.00   1.000    -
.2847221     .284569

VisitExtenOff |  -.0843611    .127675    -0.66   0.509    -
.3345996    .1658774

        _cons |  -1.089842   1.156451    -0.94   0.346    -
3.356444    1.176759

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-----------------

cooperative   |

        AgeHH |  -.0021005   .0077261    -0.27   0.786    -
.0172433    .0130424

        SexHH |  -.1241839   .1232564    -1.01   0.314    -
.3657621    .1173942

      marital |  -.0147593   .1856442    -0.08   0.937    -
.3786152    .3490966

       EducHH |  -.0242097   .0937584    -0.26   0.796    -
.2079727    .1595534

         HSiz |  -.0417164   .0411778    -1.01   0.311    -
.1224235    .0389907
```

```
    HFarmExpe |  -.0008078   .0522874    -0.02   0.988    -
.1032892    .1016736

    lnHIncome |   .0082361   .0698624     0.12   0.906    -
.1286916    .1451639

    DistanMkt |  -.0010459   .0028233    -0.37   0.711    -
.0065795    .0044877

  HAssetTrans |   .1378297   .2531939     0.54   0.586    -
.3584213    .6340806

        trust |   .1473863   .1187239     1.24   0.214    -
.0853082    .3800808

    AccMktInf |  -.4144102   .3112548    -1.33   0.183    -
1.024458     .195638

 HTrainPotato |   .0260829   .1233481     0.21   0.833    -
.2156748    .2678407

VisitExtenOff |   .2712807    .119686     2.27   0.023
.0367004    .5058609

       _cons |    .838384   1.044701     0.80   0.422    -
1.209193    2.885961

--------------+----------------------------------------------
-----------------

collcentre    |

        AgeHH |  -.0012976   .0083187    -0.16   0.876    -
.0176019    .0150067

        SexHH |  -.0491748   .1390423    -0.35   0.724    -
.3216927     .223343

      marital |  -.1932897   .2035998    -0.95   0.342     -
.592338    .2057586

       EducHH |   .0052375   .1023923     0.05   0.959    -
.1954478    .2059228

         HSiz |   -.040094    .042908    -0.93   0.350     -
.124192    .0440041
```

```
    HFarmExpe |  -.0063667   .0535981    -0.12   0.905     -
.111417    .0986835

    lnHIncome |   .2943011   .0752785     3.91   0.000
.1467579    .4418442

    DistanMkt |  -.0012356   .0027054    -0.46   0.648    -
.0065382    .0040669

  HAssetTrans |   .1681144   .2933828     0.57   0.567    -
.4069054    .7431341

        trust |   .1401734   .1297335     1.08   0.280    -
.1140995    .3944463

    AccMktInf |     .44008   .3206514     1.37   0.170    -
.1883851    1.068545

 HTrainPotato |  -.0537836   .1325399    -0.41   0.685     -
.313557    .2059897

VisitExtenOff |   .0654925   .1267651     0.52   0.605    -
.1829626    .3139475

        _cons |  -3.198235   1.106507    -2.89   0.004    -
5.366948   -1.029522

--------------+----------------------------------------------
-----------------

processor     |

        AgeHH |   .0019406   .0103151     0.19   0.851    -
.0182767    .0221579

        SexHH |   .0682316   .1652682     0.41   0.680    -
.2556881    .3921514

      marital |   .4219783   .2867543     1.47   0.141    -
.1400498    .9840064

       EducHH |  -.2657651   .1343493    -1.98   0.048    -
.5290848   -.0024454

         HSiz |  -.1303149   .0553158    -2.36   0.018    -
.2387318    -.021898
```

```
    HFarmExpe |   .0758047   .0695874     1.09   0.276    -
.0605841    .2121935

    lnHIncome |  -.3840277   .1177571    -3.26   0.001    -
.6148272   -.1532281

HHMembFarmOrg |   .0157999   .1768019     0.09   0.929    -
.3307255    .3623253

    DistanMkt |  -.0052551   .0028096    -1.87   0.061    -
.0107617    .0002516

  HAssetTrans |  -2.193007   .4669084    -4.70   0.000    -
3.108131   -1.277884

        trust |  -.1097053   .1569814    -0.70   0.485    -
.4173832    .1979727

    AccMktInf |   .2054041   .2905623     0.71   0.480    -
.3640876    .7748958

 HTrainPotato |  -.1476322   .1782061    -0.83   0.407    -
.4969097    .2016453

VisitExtenOff |  -.1202595   .1660071    -0.72   0.469    -
.4456275    .2051085

        _cons |    3.94809   1.641094     2.41   0.016
.7316041    7.164576

--------------+-----------------------------------------------
-----------------

    /atrho21 |   .5621131   .0861625     6.52   0.000
.3932378    .7309884

-------------+-----------------------------------------------
------

    /atrho31 |  -.1887314   .0945359    -2.00   0.046    -
.3740184   -.0034443

-------------+-----------------------------------------------
------

    /atrho41 |   .0645242   .0834635     0.77   0.439    -
.0990612    .2281096
```

```
-------------+------------------------------------------------
------

    /atrho51 |   -.192313   .0746983    -2.57   0.010    -
.3387189    -.045907

-------------+------------------------------------------------
------

    /atrho61 |  -.3308298    .083681    -3.95   0.000    -
.4948415    -.166818

-------------+------------------------------------------------
------

    /atrho71 |  -.0970552   .1042604    -0.93   0.352    -
.3014018    .1072914

-------------+------------------------------------------------
------

    /atrho32 |  -.1866191   .0786055    -2.37   0.018    -
.3406832   -.0325551

-------------+------------------------------------------------
------

    /atrho42 |  -.0155259   .0732597    -0.21   0.832    -
.1591122    .1280604

-------------+------------------------------------------------
------

    /atrho52 |  -.1875994   .0660976    -2.84   0.005    -
.3171482   -.0580505

-------------+------------------------------------------------
------

    /atrho62 |   -.171486   .0748439    -2.29   0.022    -
.3181773   -.0247946

-------------+------------------------------------------------
------

    /atrho72 |  -.0345303   .0806673    -0.43   0.669    -
.1926354    .1235748
```

```
-------------+------------------------------------------------
------

    /atrho43 |   .3201156    .090682     3.53   0.000
.1423822     .497849

-------------+------------------------------------------------
------

    /atrho53 |   .0181502   .0827749     0.22   0.826    -
.1440857     .180386

-------------+------------------------------------------------
------

    /atrho63 |   .1876866   .0887617     2.11   0.034
.0137168    .3616564

-------------+------------------------------------------------
------

    /atrho73 |   1.216748   .1556054     7.82   0.000
.9117674     1.52173

-------------+------------------------------------------------
------

    /atrho54 |   .2835913   .0725589     3.91   0.000
.1413786    .4258041

-------------+------------------------------------------------
------

    /atrho64 |   .1719109   .0807229     2.13   0.033
.0136969    .3301249

    /atrho74 |   .5043216   .1028137     4.91   0.000
.3028104    .7058329

-------------+------------------------------------------------
------

    /atrho65 |   .3474537   .0849045     4.09   0.000
.1810439    .5138636

-------------+------------------------------------------------
------
```

```
    /atrho75 |  -.0303133   .1001423    -0.30   0.762    -
.2265885     .165962

-------------+----------------------------------------------
------

    /atrho76 |   .1153395   .1066729     1.08   0.280    -
.0937356    .3244147

-------------+----------------------------------------------
------

       rho21 |   .5095436   .0637917     7.99   0.000
.3741481    .6236697

-------------+----------------------------------------------
------

       rho31 |   -.186522    .091247    -2.04   0.041    -
.3575015   -.0034443

-------------+----------------------------------------------
------

       rho41 |   .0644348   .0831169     0.78   0.438    -
.0987384    .2242337

-------------+----------------------------------------------
------

       rho51 |  -.1899767   .0720023    -2.64   0.008    -
.3263332   -.0458748

-------------+----------------------------------------------
----------------

       rho61 |  -.3192662   .0751513    -4.25   0.000    -
.4580506   -.1652876

-------------+----------------------------------------------
------

       rho71 |  -.0967516   .1032844    -0.94   0.349    -
.2925949    .1068816

-------------+----------------------------------------------
------
```

```
       rho32 |  -.1844825   .0759303    -2.43   0.015    -
.3280872   -.0325436

-------------+----------------------------------------------
------

       rho42 |  -.0155246    .073242    -0.21   0.832    -
.1577829     .127365

-------------+----------------------------------------------
------

       rho52 |  -.1854292   .0638249    -2.91   0.004     -
.306926   -.0579854

-------------+----------------------------------------------
------

       rho62 |  -.1698245   .0726854    -2.34   0.019    -
.3078579   -.0247896

-------------+----------------------------------------------
------

       rho72 |  -.0345166   .0805712    -0.43   0.668    -
.1902874    .1229495

-------------+----------------------------------------------
------

       rho43 |   .3096115   .0819893     3.78   0.000
.1414278    .4604238

-------------+----------------------------------------------
------

       rho53 |   .0181482   .0827477     0.22   0.826    -
.1430968    .1784546

-------------+----------------------------------------------
------

       rho63 |   .1855134    .085707     2.16   0.030
.013716    .3466722

-------------+----------------------------------------------
------
```

```
       rho73 |   .8386924   .0461518    18.17   0.000
.7219795    .9089986

-------------+----------------------------------------------------
------

       rho54 |   .2762257   .0670226     4.12   0.000
.1404441    .4018088

-------------+----------------------------------------------------
------

       rho64 |   .1702371   .0783835     2.17   0.030
.013696     .318633

-------------+----------------------------------------------------
------

       rho74 |   .4655091   .0805341     5.78   0.000
.2938824    .6080571

-------------+----------------------------------------------------
----------------

       rho65 |   .3341155   .0754264     4.43   0.000
.1790915      .47295

-------------+----------------------------------------------------
----------------

       rho75 |   -.030304   .1000503    -0.30   0.762    -
.2227886    .1644548

-------------+----------------------------------------------------
----------------

       rho76 |   .1148308   .1052663     1.09   0.275     -
.093462    .3134932

------------------------------------------------------------------
----------------

Likelihood ratio test of  rho21 = rho31 = rho41 = rho51 =
rho61 = rho71 = rho32 = rho42 = rho52 = rho62 = rho72 = rho43
= rho53 = rho63 = rho73 = rho54 = rho64 = rho74 = rho65 =
rho75 = rho

> 76 = 0:
```

```
           chi2(21) =  267.765   Prob > chi2 = 0.0000
```

D.3. Likelihood of farmers' choices to sell to all seven market outlets

```
    Variable |        Obs        Mean    Std. Dev.       Min
Max
-------------+---------------------------------------------------------
      pall1s |        509    .0013515    .0011448   2.10e-12
.0072523
      pall0s |        509    .0367866    .0207686   .0039495
.1456219
```