EFFECT OF CHOICE OF MARKET OUTLETS ON PROFITABILITY AMONG VANILLA SMALLHOLDER FARMERS IN ANTALAHA DISTRICT, MADAGASCAR

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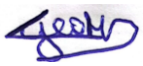
DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this University or any other for the award of a degree.

Signature  Date: 24/09/2025

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Recommendation

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

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DEDICATION

I dedicate this work to my lovely parents, brothers and all my friends, especially my father Rahelison Etienne Patine Bruno, and my dear mother Soafaravavy for their support, love, prayers, and commitment to my studies.

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ABSTRACT

Madagascar's agricultural sector is dominated by smallholder farmers, who contribute significantly to the nation's economy, employment, food security, and income. Besides that, Madagascar is the world's leading vanilla producer, primarily in the north-east, precisely in the SAVA region of Sambava, Antalaha, Vohémar and Andapa, where 87.2% of the smallholder farmers engage in the production of vanilla. However, smallholder vanilla farmers in this region still face food insecurity, lower incomes and high levels of poverty. The market outlet choices by vanilla smallholder farmers affect their profitability. This research seeks to contribute to improved livelihoods of smallholder vanilla farmers in Antalaha district of Madagascar through an understanding of the market outlet choices for enhanced profitability. The specific objectives of this research are to examine vanilla market constraints among smallholder farmers, to determine factors influencing choice of different market outlets of vanilla among smallholder farmers, to determine the profitability of participation in different vanilla market outlets among smallholder farmers and to assess the effect of market outlet choices on profitability among smallholder vanilla farmers. The study used data collected from a sample of 384 smallholder vanilla farmers from two municipalities, Ampohibe and Ambalabe, in the Antalaha districts of Madagascar. A multistage sampling technique was employed to select the respondents and cross-sectional data was collected using semi-structured questionnaires. The software Statistical Package for Social Sciences (SPSS) and STATA were employed to analyse the data. Principal component analysis (PCA) was used to group vanilla market constraints into clusters. The results revealed that smallholder farmers in both municipalities faced 14 vanilla market constraints, which were grouped into 4 principal components. Multivariate probit (MVP) results show that factors including sex, education level, off-farm income, land ownership, group membership, vanilla yield, dry vanilla, and green vanilla significantly affect the of market outlet choices among smallholder vanilla farmers. Gross margin analysis and Endogenous Switching Regression indicate that cooperatives and urban markets (6089.68 Ariary per kg) offer higher gross margins per kilogram for farmers than those who use local markets (4340.65 Ariary per kg). The research recommends that vanilla small-scale farmers should be encouraged to join cooperatives, with government support for cooperative programs, alongside improvements in education, market access, agricultural training and infrastructure. The results should help smallholder vanilla farmers to select the most profitable outlets in order to achieve higher gross margins and improve their livelihoods.

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LIST OF ABBREVIATIONS & ACRONYMS

AERC	African Economic Research Consortium
AHP	Analytical Hierarchy Process
AIVs	African Indigenous Vegetables
ANOVA	Analysis of the Variance
ATE	Average Treatment Effects
ATT	Average Treatment Effect on Treated
ATU	Average Treatment Effect on Untreated
CCER	Cellule Centrale d' Exécution du Recensement (Central Census Execution Unit)
CNV	Conseil National de la Vanille (National Vanilla Council)
ESR	Endogenous Switching Regression
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agricultural Organization Statistics
GDP	Gross Domestic Product
GM	Gross Margin
GMA	Gross Margin Analysis
GPM	Gross Profit Margin
HSD	Honestly Significant Difference
IIA	Independence of Irrelevant Alternatives
ILO	International Labour Organization
INSTAT	Institut National de la Statistique (National Institute of Statistics)
KMO	Kaiser Meyer Oklin
MCDM	Multi Criteria Decision Making
OEC	Observatory of Economic Complexity
OECD	Organisation for Economic Co-operation and Development
OIT	Organisation International du Travail (International Labour Organization)
PCA	Principal Component Analysis
PEM	Plan Emergence de Madagascar
SAVA	Sambava Antalaha Vohémar Andapa
SDGs	Sustainable Development Goals
SMEs	Small and Medium Enterprises
SNNPR	Southern Nations Nationalities and Peoples Region
STATA	Statistics and Data
UNCTAD	United Nations Conference on Trade and Development

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Vanilla is a spice formed from the fruit of an orchid (Rastogi & Bhatia, 2019). It originates from South America and Central America (specifically Mexico) as well as the Caribbean and is used in the cosmetics and food industries (Baqueiro-Peña & Guerrero-Beltrán, 2017). The vanilla bean is one of the most desirable and employed food flavours in the whole world. In addition, vanilla is used in foods, perfumes and pharmaceuticals, and it can also be applied to complementary medicinal uses such as to relieve fever, spasms, and gastrointestinal irritations (Singletary, 2020). Globally, about 40% of vanilla is sold for food purposes, whereas the rest is used for cosmetic and industrial purposes (Yoon *et al.*, 2020).

Madagascar is the leading vanilla bean producer in the world, followed by Indonesia, Uganda, India, the Comoros, and Mexico (Chambers *et al.*, 2023). The country accounts for over 80% of global vanilla production. (Gulson, 2022), with a capacity of 3,070.6 tons in 2021 (FAOSTAT, 2021). In 2020, vanilla contributed 10% of Madagascar's total GDP (Yoon *et al.*, 2020) and generated exports worth US$619 million in 2021 (OEC, 2023). Bourbon vanilla is the most commonly produced variety of vanilla in Madagascar. It is the same botanical species of *Vanilla planifolia* (Hänke, 2020; Boone *et al.*, 2022). The tropical climate of Madagascar produce well-quality vanilla that is understanded for its soft and delicate aroma (Shriver, 2013). The production is mainly cultivated in agroforestry systems in forests (Razafison, 2021).

Most of the vanilla is grown by small-scale producers employing intensive production based on traditional farming methods (Hänke *et al.*, 2018). The majority of Madagascar vanilla is from the SAVA region, where there are over 70,000 small-scale farmers cultivating this crop. The region, which spans about 25,000 hectares of land, is one of the top vanilla-producing regions in the world (Yoon *et al.*, 2020). The main production areas of SAVA are Sambava, Antalaha, Vohémar and Andapa, the last being especially popular because of its favourable relief and climate, making it highly suitable for vanilla cultivation (Raveloarijaona, 2001). Additionally, Vanilla is extremely critical to the national economy and national development since it provides the farmers with incomes that they use to buy local goods, build houses, invest in land for agriculture, and use to cover school charges (Osterhoudt, 2020).

Madagascar's vanilla sector has been growing significantly over the past decade, generating employment and contributing significantly to the country's economy, especially in

the SAVA region (Andriamahery & Zhou, 2018). Vanilla is one of the most lucrative economic development opportunities in the country, generating revenues that contribute to Malagasy people's livelihood. The production of cash crops like vanilla is also a viable strategy for the government and development stakeholders to enhance food security both in rural and urban areas (Andriamparany *et al.*, 2021).

Several issues are confronting the vanilla sector like bad control and monitoring, bad road infrastructure, weak or volatile prices, theft of vanilla, and absence of adequate information and support to farmers. (Fairfood & CNV International, 2016). Climatic disasters like cyclones and volatility in weather, price volatility in energy, are other issues hindering the production of vanilla (Jones & Murphy, 2009). Apart from that, government intervention in vanilla trade is among the most significant matters in vanilla trade (Cadot *et al.*, 2009). Market risk, by way of uncertainty in terms of price, cost, and access to the market, may compromise profitability of small-scale farmers (Wulandari, 2021). Such an issue negatively affects vanilla exports as well as farmers' livelihoods in the value chain.

In 2018, the price of Madagascar vanilla reached around US$600 per kilo (Pilling, 2018). However, the prices declined sharply in the international market to USD 250 in 2020 (Aust & Hachmann, 2021). The current price of vanilla on the local market is on average US$3.5/kg (15,000 Ariary), while the government proposed a fixed price of US$16/kg (75,000 Ariary) (Caramel, 2023). The sharp decline in vanilla prices on the international and local markets causes significant pressure on vanilla farmers' incomes and their livelihood.

Marketing of agricultural produce in Africa is achieved through various outlets depending on the produce and country. The major outlets used include farm gate, local market and urban market, cooperatives, brokers, retailers, wholesalers, assemblers, and final consumers (Arumugam *et al.*, 2022; Dessie *et al.*, 2018; Kuma *et al.*, 2013; Melese *et al.*, 2018; Sigei *et al.*, 2015; Tarekegn *et al.*, 2017). In Madagascar and indeed Antalaha district vanilla is commonly sold to local markets, urban markets and cooperatives. The different outlets that exist possess different challenges as well as opportunities. The revenue accrued from the different outlets must be explored for a better understanding of the most effective, productive, and profitable option.

The major players in the vanilla distribution chain are vanilla farmers, collectors or middle traders, exporters, importers and end buyers who are usually retailers and international food companies (Fairfood & CNV International, 2016). The main destinations of vanilla exports from Madagascar are the United States, France, Canada, Germany, and the

Netherlands (OEC, 2023). The most popular modes of transport for vanilla farmers in Madagascar include hand-carrying, bicycles, motorbikes, and cars.

To better understand the market, it is necessary to examine the factors that influence vanilla farmers' choice of market outlets and to examine the constraints of the vanilla market. There is also a need to analyse the profitability of small-scale farmers participating in different vanilla market outlets and to assess the effect of market outlet choices on profitability, with the aim of improving their standard of living and livelihoods.

1.2 Statement of the Problem

Vanilla is among the principal drivers of Madagascar's economy, accounting for a percentage of around 10% of GDP. In Antalaha district, where the majority of smallholder farmers produce this crop, the price is low because of a lack of knowledge and access to different market outlets. Currently, on the local market, vanilla sells for around US$3.5/kg (15,000 Ariary), while the government fixed the price at US$16/kg (75,000 Ariary). The choice of market outlets has a great impact on the price farmers receive and their profitability as a whole. Less choice in the market will attract monopolistic tendencies and exploitation by intermediaries, who provide prices that are less than market prices. In contrast, access to diverse and competitive outlets can improve farmers' bargaining power, increase prices, and enhance profits. Despite the significance of market access, most studies on vanilla in Madagascar have focused primarily on production rather than the marketing challenges that smallholder farmer's face. There is a dearth of scientific research on vanilla market constraints, as well as limited studies on the profitability of participation in different market outlets and the effect of market outlet choices on profitability among smallholder vanilla farmers in the Antalaha district, Madagascar. Therefore, this study seeks to address this research gaps by evaluating the impact of market outlet choice on profitability among small-scale vanilla farmers in the Antalaha District of Madagascar.

1.3.1 General objective

To contribute to improved livelihoods of smallholder vanilla farmers in Antalaha district of Madagascar through an understanding of the choice of market outlets for enhanced profitability.

1.3.2 Specific objectives

i. To examine vanilla market constraints among smallholder farmers in the Antalaha district, Madagascar
ii. To determine factors influencing choice of different market outlets of vanilla among smallholder farmers in the Antalaha district, Madagascar

iii. To determine the profitability of participation in different vanilla market outlets among smallholder farmers in the Antalaha district, Madagascar

iv. To assess the effect of market outlet choices on profitability among smallholder vanilla farmers in Antalaha district, Madagascar

1.4 Research Questions

i. What are the constraints on the vanilla market among smallholder farmers in the Antalaha district of Madagascar?

ii. What are the factors influencing the choice of different market outlets for vanilla among smallholder farmers in the Antalaha district, Madagascar?

iii. What is the profitability of participation in different vanilla market outlets among smallholder farmers in the Antalaha district, Madagascar?

iv. What is the effect of market outlet choices on profitability among smallholder vanilla farmers in Antalaha district, Madagascar?

1.5 Justification of the Study

Understanding the effects of market outlet choice on the profitability among the smallholder vanilla farmers is very important for the improvement of vanilla marketing, increasing the revenue of small-scale farmers and their welfare. Vanilla production is the primary source of revenue for small-scale farmers in the Antalaha district (SAVA region), a significant vanilla-producing area in Madagascar. Identification of the most significant market constraints is the foundation for creating market-specific interventions to enhance market performance. The aim of this study is to identify potential constraints for every market outlet and to make recommendations that should be unavoidable in a bid to enhance the marketing of vanilla within the district. Through the evaluation of market outlet determinants for market outlet selections, profitability from accessing various market outlets, and how market outlet selections influence profitability, the findings of this study inform the government in developing policies and regulation strategies to establish vanilla marketing, enhance farmers' earnings, and enhance their livelihoods and help in sustainable vanilla cultivation.

This research contributes to the realisation of Madagascar Vision 2030 which aims at reducing the poverty rate to less than 25% in 2030, improving incomes and increasing GDP per capita. The study also contributes to Madagascar Emergency Plan (PEM) which targets to empower communities, promote modernization and improve incomes. The study contributes to the attainment of Sustainable Development Goals (SDGs) 1 and 2 which are, to end poverty and end hunger and achieve food security.

1.6 Scope and Limitation

The research was conducted in the Antalaha district of the SAVA region, Madagascar. It focused on smallholder vanilla farmers. A well-structured questionnaire was employed to collect information on socio-demographic, economic, institutional and marketing factors. The collection of data was undertaken between June and July 2024, and the recall period covered the previous year of production. The study concentrated exclusively on the choice of smallholder vanilla farmers in different market outlets. The research was limited to Antalaha district, which is a major vanilla-producing area in Madagascar. The results therefore cannot be fully representative of all smallholder vanilla farmers in Madagascar. The study targeted 384 respondents who were a representative sample for smallholder vanilla farmers in Antalaha district. The study was constrained by targeted smallholder vanilla farmers did not have kept their records. This was mitigated by interviewing respondents using alternative probing to obtain the required information. The limited formal education was a challenge for the collection of accurate data from the respondents. This limitation was addressed by translating the questionnaire into the local language (Malagasy) to facilitate better understanding and more accurate responses.

1.7 Definition of Terms

Economic factors: are factors that influence the overall economy, as well as individual businesses.

Institutional factors: refer to the formal and informal rules of society that constrain behaviour. They are crucial, particularly liquidity, the reliability of professional services, and the availability of market information.

Livelihoods: are the activities and access to resources that determine the standard of living of smallholder vanilla farmers. Livelihoods include the capabilities, assets and activities needed to make a living (Majale, 2002).

Market channel: refers to the path or route through which vanilla moves from smallholder farmers to the final buyers, via intermediaries such as collectors, cooperatives.

Market outlet: refers to the various channels through which smallholder vanilla farmers in Antalaha sell their products, including local markets, urban markets, and cooperatives.

Marketing: refers to the process by which smallholder vanilla farmers in Antalaha select and access different market outlets to sell their products.

Profitability: refers to the capacity of smallholder vanilla farmers to earn a positive return or surplus from their activities after covering their expenses.

Smallholder farmers: refer to small-scale farmers who produce vanilla on land. They mainly produce on farms of less than one hectare, with an area or land size of around 0.5 hectares.

Socio-demographic factors: are the characteristics of a population.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter includes a review of the literature. The empirical literature, theoretical framework and conceptual framework will be presented.

2.2 Overview of Vanilla Production in Madagascar

Most developing countries in Africa like Madagascar depend on agricultural output as their major source of income (Boone *et al.*, 2022). Vanilla represents a major cash crop in Madagascar, contributing around 10% of the country's GDP (Boone *et al.*, 2022; Yoon *et al.*, 2020). Vanilla is an essential export commodity contributing 19% to Madagascar's export value annually (OEC, 2023). The revenue received by smallholder farmers from the sale of vanilla enhances nutritional status and food security in local agricultural communities through better access to affordable food (Andriamparany *et al.*, 2021). The revenue from vanilla equally contributes to reducing poverty in rural zones in Madagascar.

Vanilla is an orchid, which requires shade and is grown in agroforestry systems to be viable as a commercial crop. The vanilla culture is native to Central America, it was brought to Madagascar in the 19th century by the French. (Hänke, 2020). Vanilla grown on Reunion Island, Madagascar, Mauritius, and Seychelles is derived from a single *Vanilla planifolia* (Arya & Sangram Keshari Lenka, 2019). Besides, the vanilla grown in Madagascar is the same botanical species of vanilla (*Vanilla planifolia*) in Uganda with a distance of about 3,500 km between the two vanilla growing regions (Boone *et al.*, 2022). Vanilla pods from Madagascar and East Africa "vanilla bourbon" are the best vanilla pods.

Vanilla production in Madagascar is concentrated in the eastern coastal zones of the country, especially in the north-eastern region of SAVA, with a small amount also produced in the southeast. Moreover, more than 80,000 of the population in Madagascar are smallholder vanilla farmers. Between 80-90% of vanilla produced is vanilla Bourbon on approximately 25,000 hectares of land (Fairfood & CNV International, 2016). Madagascar is the world's leading vanilla producer with an 80% global market share (Boone *et al.*, 2022; Gulson, 2022) with a production capacity of 3,070.6 tons as of 2021 (FAOSTAT, 2021). In Madagascar and other regions of the world, vanilla orchids must be hand-pollinated (Boone *et al.*, 2022; Hänke *et al.*, 2018). While in Central America the plant is pollinated in the wild bees (Boone *et al.*, 2022). The yellow vanilla flower only blooms once a year and usually remains open for only a few hours. Pollinating flowers requires a lot of handwork. Manual pollination generally takes place between October and January (Hansen *et al.*, 2016). The

time between planting and pollination is three years and from the time of pollination, it takes seven to nine months for the vanilla to be mature and ready to harvest (Boone *et al.*, 2022). Vanilla can be harvested from June to August. It requires six kilograms of green vanilla pods to obtain one kilogram of dry vanilla. Once harvested, vanilla undergoes a long and complex process to develop an aromatic compound called vanillin, as well as other aromatic components.

2.3 Constraints of Vanilla Marketing in Madagascar

Climate change that is evidenced though constant hurricanes and cyclones is a big problem for cultivation, especially for outdoor cultivation in the tropics (Boekhout, 2022). For example, in 2017, cyclone Enawo caused great damage to smallholder vanilla farmers in Madagascar hence disrupting the global vanilla trade (Purdy, 2017). In addition, vanilla thefts in the fields and the drying process have become major constraints in the region (Fairfood & CNV International, 2016). Moreover, snails and slugs are pests that can cause problems for vanilla plants, as they like to nibble on the roots and leaves of the plant (AgNet West, 2021). Land insecurity prevents smallholders from investing in more labour-intensive crops and production on untitled land (Crowl, 2014).

The largest number of smallholder vanilla farmers sell their vanilla on the informal market and this often leads to several intermediaries (Hänke *et al.*, 2018). Smallholder vanilla farmers are paid unstable and low prices, and the market is poorly organized (Fairfood & CNV International, 2016). This is why vanilla producers are abandoning their fields because of very low vanilla prices. Besides, the lack of transparency and the unreliable market is also a big marketing challenge. The Covid-19 pandemic caused also the price of vanilla to fall due to the price control policy launched during this period (Caramel, 2023). This pandemic caused delays in the commercial operations of vanilla beans in various countries including China, the United States, Germany and South Korea (Scoot, 2020). Furthermore, most farmers are largely separated from exporters giving collectors an opportunity to purchase at low prices from smallholders and resale at higher prices to exporters.

The quality of Madagascar's vanilla harvest is highly affected by theft. As a result, farmers are forced to harvest before the vanilla is mature to decrease the risk of theft, which negatively impacts quality(Hänke *et al*., 2018, Marion, 2019). Corruption also leads to a drop in vanilla quality, as thieves and impatient smallholders alter the moisture content and sell inferior vanilla beans (Holland & Rabary, 2019).

Smallholder vanilla farmers' lack of price information at all market levels and they are not allowed to trade at market level. Because, exporters decide the price and determine

the decision of the vanilla platform before the harvest (Fairfood & CNV International, 2016). They are not included in decision-making, such as setting the harvest date, and do not understand how prices are determined. Smallholder vanilla farmers lack access to training, resources such as agricultural equipment, tools, financial means to pay for the work, information, and the technical skills/capabilities required to produce quality vanilla (CNV). In this sector, vanilla is uncontrolled and unregulated, and corruption is also present. Moreover, lack of a standardized grading system for vanilla, which smallholder farmers use based on appearance and size (Yoon *et al.*, 2020).

Most rural areas of Madagascar, especially the SAVA region, lack road infrastructure (OIT, 2023). Hence, poor infrastructure and lack of access to roads prevent smallholder farmers from accessing the market (CNV). Vanilla sector management is poor, as the products of smallholders and collectors are exposed to risks, with several losses due to the large number of storage facilities (Zoelle, 2023).

New regulations announced by the government in 2020, including a minimum export price, mandatory foreign currency repatriation of all revenues, and the creation of a Vanilla National Council, are raising doubts among buyers and some exporters (Caramel, 2023). This regulation and state intervention in the export price implies a drop in the price of vanilla. In addition, political instability has had a detrimental effect on vanilla exports in Madagascar, leading to a reduction in economic growth (Andriamahery & Zhou, 2018). The political instability affects small-scale farmers through market disruption, insecurity and price volatility.

2.4 Smallholder Farmers' Participation in the Marketing of Agricultural Produce

2.4.1 Choice of market outlets

The choice of market outlet is a vital element in the decision to participate in the market. Selecting a point of sale is an essential decision for farmers when it comes to vending their farm products. Many smallholder farmers, however, have limited options and cannot always sell their products at profitable prices (Arumugam *et al.*, 2022). For small-scale farmers, the outlet they select can significantly affect their income and is often considered a household-level decision, influenced by multiple factors (Abera, 2016). Selecting the right market also allows farmers to align their resources, goals, and location with the most suitable outlet (Riziki, 2015). In practice, the point of sale can directly influence the price received (Mburu, 2015), and farmers tend to choose outlets that offer the highest returns considering price variability and other benefits.

Farm gate, local market, urban market, brokers, retailers, wholesalers, assemblers, and ultimate consumers are the primary market outlet options (Arumgum *et al*., 2022; Dessie *et al*., 2018; Kuma et al., 2013; Melesse *et al.*, 2018; Sigei *et al.*, 2015; Terekgn *et al*., 2017). In Antalaha district of Madagascar, vanilla from smallholders is generally sold to local collectors on the local market, to traders or middlemen on urban market, and to cooperatives. However, local markets and cooperatives are frequently considered by many small-scale vanilla farmers to be buyers of convenience, as they usually offer ready markets. Smallholder vanilla producers sell their products at very poor price due to the asymmetry of information between intermediaries and small-scale farmers.

2.4.2 Market participation

Market participation consists of both access to input and output markets for small-scale farmers and other actors in the value chain (Mugonola *et al*., 2017). Marketing participation is an individual's ability to participate effectively and efficiently in a market (Andaregie *et al.,* 2021). Marketing participation can be described as the players' improving engagement with markets (Mugonola *et al.,* 2017). Market participation presents to the percentage or quantity of production harvested that is traded (Sebatta *et al.,* 2014). Furthermore, market participation leads to increased proportions of crops and animal products destined for sale (Mugonola *et al.,* 2017).

The participation of small-scale farmers in developing countries in the market is very weak, which decreases the economic growth generated by farming and increases poverty, since smallholder farmers do not get the gains in wellbeing and greater incomes (Mango *et al.,* 2018). Moreover, there are a number of barriers and constraints that reduce small-scale farmers' incentives to participate in the market, making it very difficult for them to do so. (Okoye *et al.,* 2016). Additionally, farmers in many developing countries frequently lack access to information on markets with high added value (Sumari et *al.*, 2018). The high transaction costs also prevent smallholder farmers making much of a contribution to these markets (Okoye *et al.,* 2016). As a result, increasing transaction costs make it difficult for farmers to obtain detailed feedback on the market (Mbembela, 2019).

Market participation remains crucial for the smallholder farmers since it has the potential to improve productivity and support poverty alleviation (Akrong *et al.,* 2021; Manda *et al.,* 2020). Market participation offers greater incomes and enhances the food security of the population (Kyaw et al., 2018; Manda *et al.,* 2020). It also provides employment and income to the rural smallholders, thus promoting farming and economic growth. By linking farm inputs and outputs more effectively, market participation can help

farmers increase their production, prices, and income level (Gebremedhin & Jaleta, 2010; Kabeto, 2014; UNCTAD, 2015). Better market access can make farmers move from subsistence to commercial farming and, thus, improve their standards of living (Sebatta *et al.*, 2014; Waweru, 2019).

The vanilla market in Madagascar concerns four main groups of participants: vanilla producers, collectors, export companies, and international traders (Yoon *et al.*, 2020). The majority of vanilla producers are smallholders who plant small plots, who depend heavily on family labour and have limited funds (FAO, 2019). Farmers are the main source of vanilla pods and provide the majority of the market. In general, they market their vanilla locally, sometimes directly from their houses or farms, or via collectors (Fairfood & CNV International, 2016). Smallholder farmers cannot access international markets as they are unable to negotiate favourable prices and their scale of production is limited. The participation of small-scale vanilla growers in the market contributes to the livelihoods of these communities and to local economies.

Collectors are middlemen who buy vanilla beans directly from farmers. They sell it directly to processors and exporters or export it to countries where the vanilla beans are processed (Steenbergen, 2022). Collectors may provide vanilla bean basic drying before they are sold to processors or exporters. Collectors can also be employed as experts in vanilla quality control. In addition, those who work in transportation and logistics are essential components of collectors. The actions of collectors support the vanilla supply chain's general effectiveness and functionality. While, players in the vanilla supply chain improve market conditions (Kyerere *et al.*, 2021).

Exporters are the companies or entities responsible for shipping vanilla beans to international markets or international traders. Exporters often work closely with farmers, traders, and processors to source vanilla (Fairfood & CNV International, 2016) and ensure compliance with international standards and legislation (United Nations, 2008). Therefore, exporters buy vanilla from collectors or traders, as well as from processors, but in some cases, they also buy it directly from farmers. Exporters are primarily responsible for quality control; they pay special attention to product quality and references, particularly when exporting to countries like Europe (Yoon *et al.*, 2020).

International traders of vanilla are usually companies or other entities engaged in the international trade and processing of vanilla products. International traders are responsible for negotiating export prices and are the intermediaries between exporting firms and the international enterprises that buy and process vanilla into finished products. International

traders have relationships with vanilla growers, collectors and major exporters in these countries that produce vanilla. The United States, Germany, France, Canada and the Netherlands are the main importers of Madagascar vanilla beans (OEC, 2023). International traders often have an incentive to participate in the international marketing in order to make more profit. Sometimes they buy goods at a cheaper price in one market and sell them at a higher price in another. Additionally, they may serve as exporters when shipping commodities overseas and as importers when importing products into a nation. Therefore, they make it easier to buy and sell vanilla on the international market.

2.5 Factors Influencing Choice of Market Outlets among Smallholder Farmers

Many studies on the marketing outlet choices by small-scale farmers reviewed in the literature have employed multinomial logit and multivariate probit models in their analysis. Sigei *et al.* (2015), utilised a multinomial logit model to reveal that sex, group marketing, pineapple production, information on prices, contract marketing, and ownership of a vehicle had significant impacts on the selection of marketing outlets for pineapples in Kenya. Multinomial logit model used by Kuma *et al.* (2013) showed that the number of cows, price, land size, agricultural experience, access to extension, and mode of payment influenced the choice of milk market outlet channel in Ethiopia. Additionally, a study employing a multinomial logit model demonstrated that gender, source of income, and membership in a group affect smallholders' decisions to sell their IAVs to brokers, retailers, or wholesalers (Arumugam *et al.*, 2022).

Dessie *et al.* (2018) applied a multivariate probit model to show how wheat farmers' choice of marketing option is determined highly by age, education, access to credit, ownership of cattle, non-farm income, and farm size. Applying the same model, Addis *et al.* (2019) explained that wheat sale to wholesalers, collectors, or cooperatives in Dembecha district was specified as a function of education level, amount of wheat supplied, size of family, membership in cooperatives, and exposure to agricultural extension services. Tarekegn *et al.* (2017) established that the point of sale decision by beekeepers was determined by income level, honey quantity sold, frequency in which distributors are seen, experience in beekeeping, distance to the nearest market, market information, organizational membership in a cooperative body, and buyers' trust.

Mengstu *et al.* (2023) utilised a multivariate probit model of the factors that influence the selection of market outlets by bamboo farmers in Ethiopia. Likewise, Abera (2016) analysed smallholder bean farmers in the Misrak Badawacho district utilising a multivariate probit model. The research demonstrated that the decision to select urban traders was

influenced by factors like distance from all-weather roads, distance to nearest regional market, number of horses owned, utilization of credit, membership of a cooperative, and price information.

Ng'ang'a *et al.* (2022) operated a multivariate probit model and found that farmers' experience in bean cultivation, farm size, training and credit access, and participation in partnerships positively influenced sales at commercial outlets in Homa Bay County, Kenya Alemayehu and Alemu (2022) used the same model to examine smallholder coffee producers' choices regarding commercial outlets in Ethiopia. Their research showed that access to credit had a negative impact on the choices of retailers, processors and consumers, while distance to the nearest market had a negative effect on the decisions of processors and engagement in non-agricultural activities had a positive effect on the options of retailers and consumers. Njjengo (2024) analysed vanilla smallholders and found that experience, education level, distance to markets, sales price and size of household were critical influences on their decisions on market outlets.

2.6 Factors Influencing Market Participation among Small-scale Farmers

Mbitsemunda and Karangwa (2017) used a probit model to examine the determinants of smallholder bean farmers' market participation and found that the probability of participating in the production market for beans was positively related to the quantity of beans grown, market experience, and access to credit. Conversely, factors such as distance to the nearest market, age, and involvement in non-agricultural activities reduced the likelihood of farmers participating.

Sumari *et al.* (2018) applied a binary logit model to analyse how small-scale vegetable producers in Tanzania participate in high value-added markets. The study reveal that farmers' participation was impacted by factors such as revenue, distance of the farm from the main road, productivity, irrigation, access to extension services, availability of market information, and distance to high value-added markets. Applying the multinomial logistic regression model, Mustapha (2017) analysed the determinants of smallholder farmers' market participation in Ghana and found that women farmers, access to credit, increased farm size and household size discouraged subsistence agriculture and encouraged market-oriented agriculture.

Applying Heckman's two-stage selection model, Kyaw *et al.* (2018) examined influencing factors on smallholder rice farmers' market participation in the Magway region of Myanmar's central dry zone and found that the choice to participate in the rice market depended on various factors including the head of household's age, education level,

household size, total rice production, rice prices, household revenue, livestock ownership, membership in a farming organisation, access to roads, distance to the market, access to extension services, and information about the market. Worku *et al.* (2022) employed Heckman model to investigate the factors that affect smallholder chickpea market participation and volume of marketed surplus of chickpea in Este Woreda. The results show that the decision to participate in the market had a significant influence on age, family size, deferred price, and distance to market, while participation in the market had an impact on the frequency of contact with extension services, quantity of production, ownership of transport, and distance to market.

Applying the triple hurdle model, Akrong *et al.* (2021) analysed the determinants that influence small-scale farmers to access high-value mango markets in Ghana and found that participation in these markets affected by the education level, income of the household, agricultural experience, ownership of motorised transport and a radio, trust, distance from the road, certification and credit access. The findings also indicate that access to export markets was influenced by size of household, income of household, agricultural experience, distance to tarmac roads, and price. Using the triple-hurdle model, Okoye *et al.* (2016) examined the impact of transaction costs on participation in the market of small-scale cassava producers in central Madagascar.

Amato (2018) analysed the impact of cooperative participation on vanilla farmers in Madagascar and used regression analysis. This study showed that cooperative participants on average prices for vanilla and saw an important reduction in price dispersion in comparison to non-participants. A study by Bremm (2015) examined the factors that affect the strategic commercial perspective on smallholder vanilla farmers' organisations in Mexico. This study revealed that producer associations initially chose three different strategies in order to deal with their vulnerability and gain market power: size, cutting out the middlemen, vanilla quality assurance, and biodiversity conservation.

2.7 Profitability of Participation in Market Outlets

Profitability is generally considered to be the capability of a given investment to provide a return on its use (Nishanthini & Nimalathasan, 2013; Toshniwal, 2016). Profitability helps to analyse and critically interpret enterprises' current and future earning power (Toshniwal, 2016). It is also important that it exists within a company to help guide the behaviour of managers and other employees. Profitability constitutes a major indicator of the overall achievement of a company (Nishanthini & Nimalathasan, 2013). Gross profit and gross margin are two measurements of profitability. Gross margin is a measure of

profitability used to examine a business's financial well-being. It represents the relationship of gross profit to revenue as a percentage. Gross profit represents the profit remaining after subtracting the cost of goods sold from revenue.

Gambo (2017) used the Gross Margin model to analyse profitability in various markets for perishable and non-perishable agricultural products in Nigeria. The study found that vegetable traders realised more profit than grain traders. Keru (2021) employed gross margin to examine the factors influencing the profitability of coffee market outlet choice for producers in Kenya.

Evans (2011) used gross margin analysis to analyse the technical efficiency of sweet corn production and compared the profitability of sweet corn production with other crops among smallholder growers in Kenya. The study indicated that sweet corn production was not technically efficient. Positive factors influencing efficiency included land ownership with title deeds, use of hired labour, and involvement in non-agricultural activities, while age and gender of the household head had negative effects. Overall, sweet corn production appeared to yield higher returns compared to other farming activities in the region. Similarly, Adams *et al.* (2021) used gross margin analysis to examine how tomato farmers' choices of marketing options affected profitability in Ghana. The findings suggest that producers who sell to wholesalers tend to be more successful than those who supply retailers.

Wachira et al. (2014) employed gross margin and net profit to compare the profitability of small-scale tomato production systems in greenhouses and open fields in Kenya. The study show that the average net profit/m2 for tomatoes grown in greenhouses was over ten times greater than that of the open-field tomato system of cultivation.

Kadigi (2013) applied gross margin analysis to assess and analyse the profitability of formal and informal actors in the dairy value chain in Iringa and the Tanga urban. The results showed several policy measures, including proposing an affordable price per litre of milk, mutual aid for collective actions, offering non-financial incentives, reorganising existing dairy institutions, creating milk collection centres, stimulating added value and investing in milk production. The study also found that players in the municipality of Iringa earned relatively higher profits than those in the city of Tanga, with informal players in the dairy sector in both locations earning higher profits than their counterparts in the formal dairy market. The study also found that the Iringa municipality players were comparatively more lucrative than the players in the Tanga city, and that the informal players in the dairy sector in the two municipalities were more lucrative than the players in the formal dairy business.

Karane (2016) analysed the factors that impact the profitability of common bean cultivation among smallholder farmers in Tanzania. The research used gross margin to calculate the gross margin earned by small-scale producers growing common beans and found that farmers' age, gender, yield, selling price, credit access, and non-agricultural income had an impact on the gross margin earned by small-scale farmers. Zulu (2011), analysed the profitability of cowpea producers in Zambia. The study employed the gross margin model and found a positive effect of yields, land tenure, and farm gate prices on profitability, while production costs and area had a negative effect on profitability. Similarly, Olujenyo (2008) assessed the factors that influence maize production profitability in Nigeria. The study found a positive effect of age, education level, labour, and non-labour input costs on output, whereas the size of the farm and years of experience had a negative effect. Labour alone has a significant effect on production.

Santosa *et al.* (2005) conducted a study to establish the profitability of vanilla intercropping in Indonesia pine forests and found that vanilla growing in pine forest was much more profitable than pine intercropping with commercial crops or bananas. Moreover, the income levels of farmers were directly related to intercropped vanilla areas but inversely related to the rice land sizes. The result also demonstrated that vanilla farming increased growers' income levels with small or no rice land. The study showed that more land of intercropped vanilla was associated with higher farmer income, while rice farm size declined. Vanilla production, particularly, was linked to higher farmer income for farmers who had minimal or no rice land.

2.8 The Effect of Market Outlet Choices

Adugna *et al.* (2019) used F-statistics to examine the effect of market outlets on income and productivity in the Lake Tana Basin, Ethiopia. They found that higher productivity and income was derived by those households selling both at farm gate and at local markets. Similarly, Ozkan *et al.* (2022) demonstrated the factors influencing market outlet selections and how they impacts the welfare of small-scale fruit and vegetable farmers in Ethiopia. Their study showed that farmers’ decisions were affected by proximity to main roads, holding livestock, extension service accessibility, and cooperative membership determined the farmers' decision.

Silva (2015) studied the effect of marketing channels on producers' satisfaction with the quality of life and profitability among organic vegetable farmers in Wisconsin. The study found that producers selling at farmers' markets and through community-supported agriculture are less satisfied with their profits. In contrast, those selling at wholesale markets

and to institutions or restaurants are less satisfied with their living. Naseer *et al.* (2019) analysed how the choice of marketing channel affects the profits of citrus fruit producers in Pakistan. The study applied a multinomial treatment effects model. It found that farmers' profits increased when they participated in marketing channels, like those run by processors and entrepreneurs.

Seatle (2022) analysed how choices of marketing channel impact profit of vegetable smallholder growers in Lesotho. The research employed gross margin analysis to evaluate the profitability of various vegetable distribution channels. It found that selling vegetables through formal marketing was more profitable compared selling through informal marketing. Park *et al.* (2018) used treatment effects with multinomial selectivity in examining the impacts of direct marketing choices on sales. The findings showed that the penalty linked to direct marketing is significant. This is particularly due to key demographic factors, farm experience, Internet use, and farm characteristics such as crop choice and the use of inputs.

2.9 Critique of the Literature

Madagascar is the world's largest supplier of vanilla, accounting over 80% of world production (Gulson, 2022). Despite this, the dominant share of vanilla production in Madagascar, there is no available data on production statistics, export volumes, price dynamics and the socio-economic effect on vanilla farmers. Further, vanilla cultivation in Madagascar faces many challenges, including climate change, crop diseases, and the role of intermediaries in the supply chain. These problems can lead to price volatility and decrease farmers' revenues. Most studies focus on market outlet and participation for crops like pineapples, beans, coffee, and vegetables, and very little scientific research on vanilla. From the literature that has been reviewed, it is evident that research has focused largely on food and cash crops that can be alternatively used for home consumption. Unlike other crops, vanilla is a unique cash crop that cannot be directly consumed at home unless processed. Consequently, Vanilla is a unique cash crop, so the factors that influence farmers' choice of market outlets and their participation may differ from those for other crops. It is also highly labour-intensive, making it a very valuable agricultural product (Gallant, 2019). As one of the most expensive spices in the world, vanilla is not typically used for home consumption, which makes its market dynamics quite different from those of other spices.

Additionally, several studies have examined vanilla production in Madagascar, but there is limited scientific information on market outlets and how they affect the profitability of small-scale farmers. Moreover, research on the constraints of the vanilla market using techniques like principal component analysis (PCA) is also scarce. Furthermore, few studies

have explored the profitability of participating in different market outlets or the impact of sales outlet choices on smallholder vanilla farmers' income in the Antalaha district. While Madagascar's vanilla exports are substantial, there is little empirical evidence on the income gains from various market outlets (Brodwyn *et al.*, 2020). Overall, smallholder farmers' profitability depends not only on production costs but also on factors such as the type of product sold. The profitability of small-scale farmers that has been discussed in the literature concerns products which are mainly processed locally and sold at a higher added value. However, vanilla is largely sold by smallholder farmers in the form of green vanilla pods, with little or no added value, as the profitability of processed vanilla (dry vanilla) on the market outlets could be different from that of unprocessed vanilla (green vanilla).

2.10 Theoretical Framework

2.9.1 Rational choice theory

The pioneer of the theory of rational choice was George Homans (Homans, 1961). Homans established a fundamental framework for the theory of exchange, based on hypotheses derived from behaviourist psychology. In general, rational choice theory examines the choice-making behaviour of one or more individual choice-making units, which are often companies or consumers in the fundamental economic context (Coleman, 1990). The rational choice theory also suggests that buyers and sellers make decisions that help them achieve their goals, considering independent factors beyond their control (Coleman, 1990).

Rational choice is a choice made from several alternatives using rational reflection. It can be applied to various fields. This theory shows that people use their interests to choose decisions that will offer them the most benefit. The theory of rational choice is also a fundamental assumption of economic thought, according to which individuals faced with a decision choose the option that corresponds to their rational interest.

Besides, this theory is used widely in economic models, in which individuals are also considered *homo economicus*, meaning that they are rational and self-interested. Rational choice theory offers a useful framework for understanding human behavior and decision-making (Chai, 2001). Hausman (2009) explains that in economics, this theory assumes individuals evaluate a set of alternatives based on their preferences. Classical economics further suggests that people are fully aware of all possible decisions, the likelihood of outcomes, and their consequences, without cognitive limitations (Wittek, 2013). The theory also assumes that personal values and social structures influence outcomes (Hechter & Kanazawa, 1997), and that individuals act out of self-interest rather than selfishness (Hechter & Kanazawa, 1997).

This study was guided by rational choice theory to understand how small-scale vanilla farmers decide which market outlets to use. It assumes that farmers make these decisions based on rational evaluation of their options. In this research, there are three alternatives that small-scale farmers may employ to sell vanilla products including local markets (local collectors), urban markets (traders), and cooperatives. Smallholder farmers assess the factors that come into play prior to choosing a decision based on the level of happiness, satisfaction, and utility procured. The market outlet chosen for the small-scale farmer will influence the profits.

2.9.2 Utility maximization theory

The study focuses on the utility decision of smallholder farmers to choose market outlets including local markets, urban markets, and cooperatives. The choice to participate in commercialization is based on the principle of profit maximization (Norris & Batie, 1987; Pryanishnikov & Katarina, 2003). Within this structure, the marketing decisions of small-scale farmers were measured in terms of profits. Smallholder farmers aim to maximize their profits by choosing their market outlets. The profitability derived from the production and sale of vanilla can be conceptualized under the structure of utility maximization.

As an economic agent, the smallholder vanilla farmers decided to choose a given market outlet if the perceived benefit of this choice was significantly higher than the utility of other market outlets. Smallholder farmers decide on their market outlet selections by considering the profits they derive from vanilla, the main source of subsistence and revenue in this district. The small-scale farmers decide to choose the vanilla market outlets by comparing the expected utility values.

Suppose that U_j, U_k, and U_z indicate smallholder vanilla farmers' decision for three choices of market outlets Y_j, Y_k, and Y_z accordingly, the random utility model might then be determined as below:

$$U_{ij}(B_j X_i + e_j) > U_{ik}(B_k X_i + e_k) > U_{iz}(B_z X_i + e_z), \text{k} \neq \forall_i \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

From the equation above, the vanilla market outlet choices are j, k, and z respectively, whereas X_i is the vector of explanatory variables posited to affect the perceived desirability of each option.

If smallholder vanilla farmers select market outlet which is option j, and k, it consequently follows that the utility from alternatives j, and k will be greater than the utility from option z.

The probability of the smallholder farmers choosing alternative j instead of k and z might then be expressed as follows:

P (Y=1/X_i) = P (U_{ij}> U_{ik}>U_{iz}) $k{\neq}\forall_i$ …………………………………….. (2)

P (B_jX_i+ e_j $-B_kX_i - e_k - B_zX_i - e_z$> 0/X) ……………………………… (3)

P ($B_jX_i - B_kX_i - B_zX_i$ $+ e_j - e_k -$ e_z> 0/X) …………………………… (4)

P (B^*X_i+ e^*> 0/X) = F (B^*X_i) …………………………………………… (5)

where, P is the probability function of U_{ij}, U_{ik}, U_{iz}, and X_i as shown above, $\forall_i$ is supposed to be continuous with the dominant covariance matrix, e^*= e_j $-e_k$ $-e_z$ is a random error term, $B^* = B_j - B_k - B_z$ represents a vector of unknown parameters which may be interpreted as a net influence of the vector of explanatory variables, and F (B^*X_i) is the cumulative distribution function of e^* estimated B^*X_i.

The profit function will be defined below:

Y= $P_{(j,k,z)}$+ X_i + e_i ………………………………………………….. (6)

Where Y is the gross margin or gross profit margin, $P_{(j,k,z)}$ is the choice of participation in the market outlets (j= local markets, k= urban markets, and z= cooperatives), X_i is the factors that impact the market outlets, and e_i represents random disturbance term.

2.10 Conceptual Framework

The study considers smallholder vanilla farmers as the unit of analysis. The socio-demographic, economic, and institutional factors, along with market constraints influence the market outlet choices and, ultimately, the livelihoods of small-scale vanilla farmers in the Antalaha district of Madagascar. Socio-demographic factors include age, sex, education level, household size, and farming experience. The economic factors comprise off-farm income, vanilla yield, land size, and green and dry. Institutional factors involve distance to market, group membership, and land ownership. These factors, along with market constraints, likely affect farmers' decisions of selling their vanilla in local markets, urban markets, or cooperatives. The selection of market outlet influences profitability, measured by gross margin, which helps to increased livelihoods. This systematic approach helps guide research by showing the sequence and connection between factors that lead from constraints to market outlet selection, profitability, and finally improved living standards for farmers. This interaction has been represented in Figure 1.

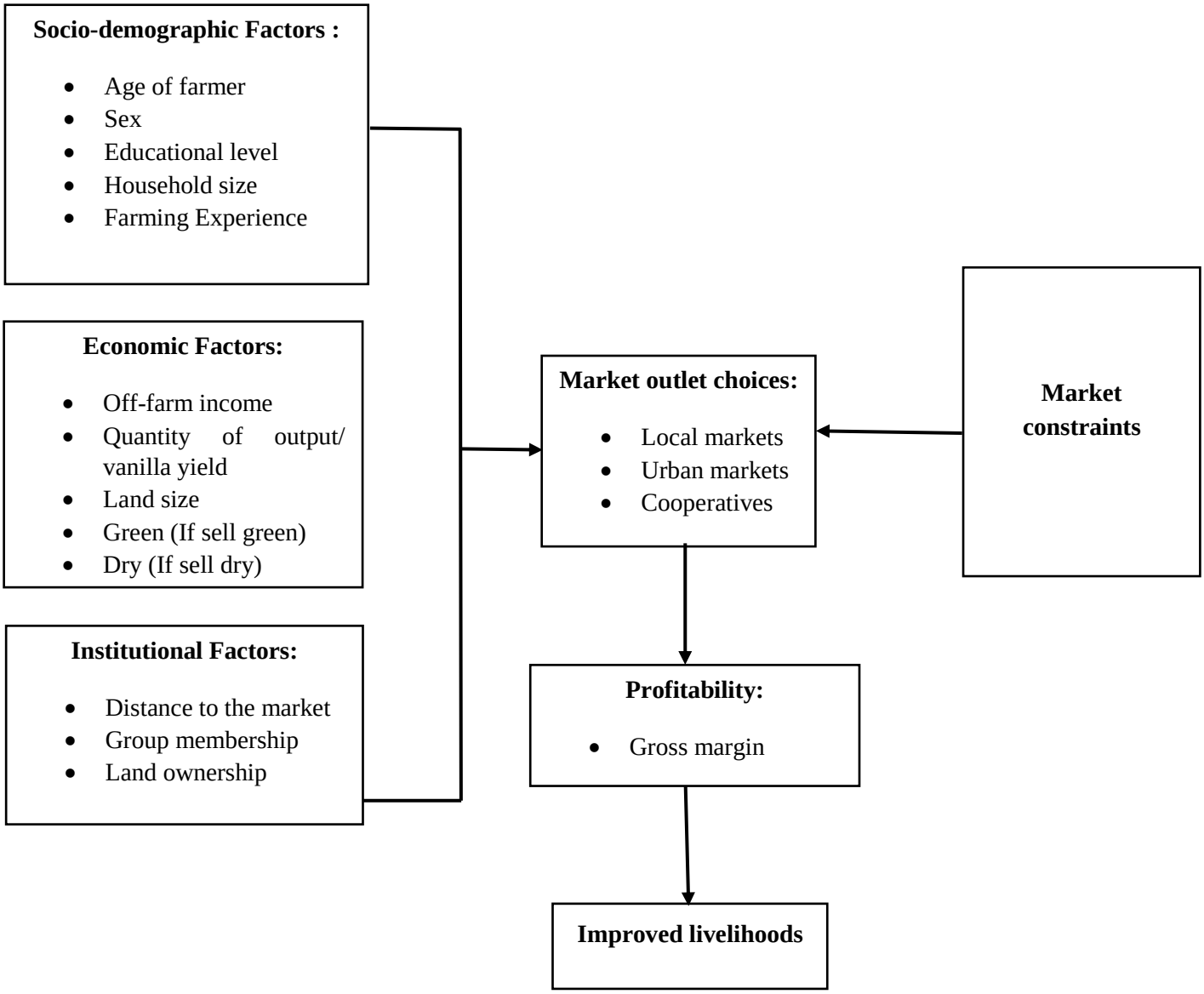

Figure 1: Conceptual framework

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the different methodologies for data collection and analysis. It starts by succinctly describing the research design and study area. It specifies the sample size, sampling procedure, and data collection. Finally, it describes the analytical framework that addresses every objective. This includes the use of principal component analysis, the multivariate probit model, the gross margin analysis, and the endogenous switching regression model.

3.2 Study Area

The research was conducted in Antalaha District, one of Madagascar's 119 administrative districts located in the northeast of the country. Antalaha covers an area of 6,795 km², Antalaha belongs to the SAVA Region including the districts of Sambava, Andapa, and Vohémar (INSTAT, 2020). An estimated population of 282,158 people with a people density of 42 people per km² is show in the district. The area has a mean annual temperature of 27.1°C, above the national average, and has an annual rainfall of about 132 mm spread over around 146 rainy days (INSTAT, 2020). Two distinct seasons exist: the rainy season, from November to April, and the dry season, from May to October, but the wettest month in Antalaha is February, with an average of 10.6 inches of rain. The latitude of Antalaha is 14º 90' south, and the longitude is 50º 28' east. Agriculture is a dominant economic activity in the Antalaha district supporting 89.7% of households (ILO, 2020). The food crops grown include rice, cassava, potatoes, maize and beans, while cash crops include vanilla, coffee, cloves and pepper. Vanilla is the most significant cash crop in the district with around 87.2% of small-scale farmers in the region growing vanilla (ILO, 2020). Poverty levels in the region are high at approximately 75% (ILO, 2020).

The Antalaha district was chosen principally because vanilla cultivation is the major occupation of the population in this district and this crop is also the main economic cash crop. In addition, Antalaha is part of the tropical and humid zone with a high potential for vanilla production. Moreover, poverty levels in the district have increased, which is why intervention measures need to be implemented to solve the problem. The study area is represented by the map in Figure 2.

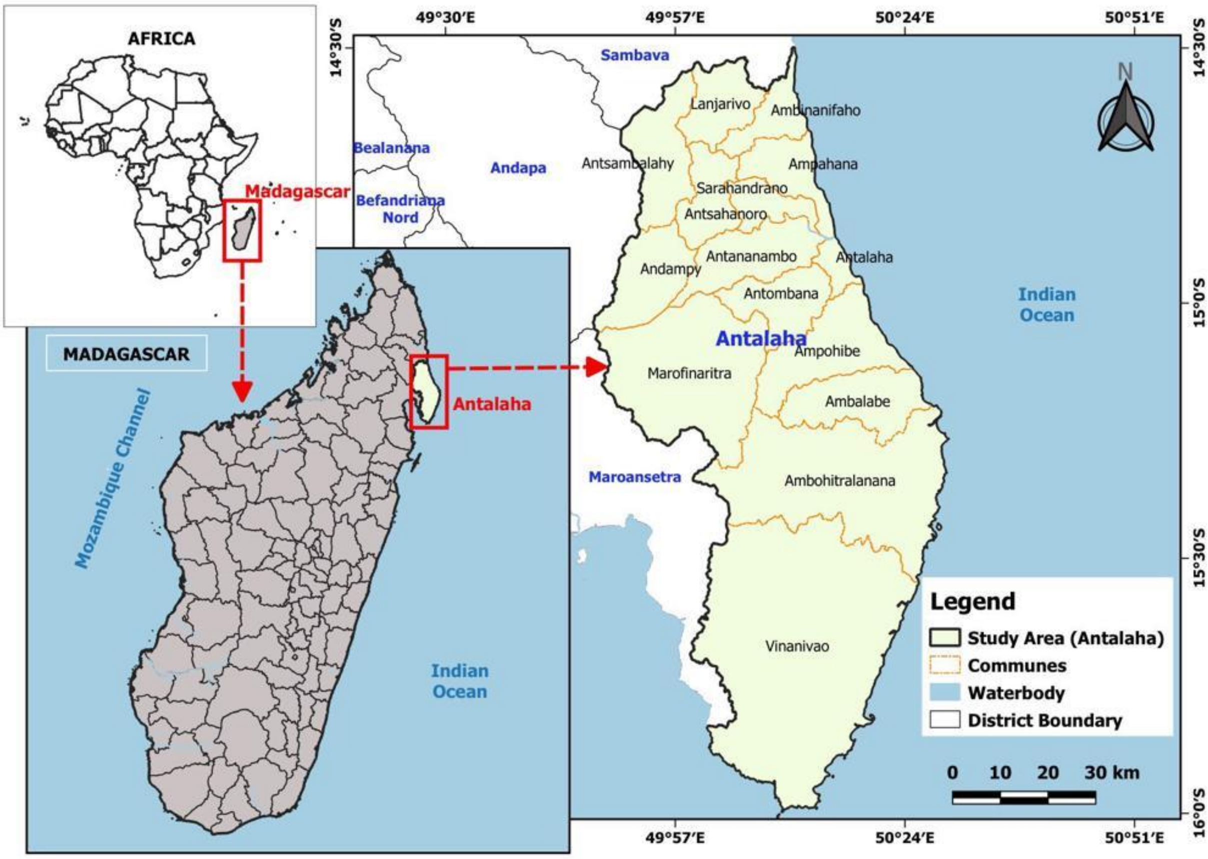

Figure 2: Map of the Antalaha district

Source: Egerton University, department of Geography, 2023

3.3 Research Design

This research employed a survey design to determine smallholder vanilla farmer's participation in different market outlets in Antalaha District. The survey employed cross-sectional data with a one-year recall period.

3.4 Sample Size Selection

The desired sample size was established using the size-proportional sampling method. This method was used because the exact number of the population targeted is not known in the study area. According to Cochran (1963) and adopted by Kothari (2004), the sample size required was calculated by the formula below.

$$n = \frac{z^2pq}{e^2} \quad \text{………………………………………………………} (7)$$

Where n = sample size, z refers to a z-value of 1.96 on the confidence level of 95% (α = 0.05).

P represents the proportion of smallholder vanilla farmers in the population which is equal to 0.5 statistically adequate and accurate sample size when the population cannot be specified.

q indicates the percentage of people in the population targeted predicted not to have the attributes being measured (proportion of non-smallholder vanilla farmers) and it is calculated as 1-p (1-0.5=0.5).

e the acceptable error 5 %. This formula was also used because the number of smallholder vanilla farmers was unknown before the survey took place.

The sample size will be calculated using the following method:

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{0.05^2} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (8)$$

$n \cong 384$

384 respondents were employed as the sample size for the vanilla small-scale farmers.

3.5 Sample Procedure

A multistage sampling technique was utilised to choose the respondents' of smallholder vanilla farmers. In the first stage, the researcher employed the technique of selective sampling to choose the Antalaha district among the four districts in the SAVA region due to the majority of vanilla production. In the second stage, the municipalities of Ampohibe and Ambalabe were purposively selected from the eighteen municipalities in this district. These two municipalities were selected because of the large number of smallholder vanilla farmers (DRAE, 2024). The third and final stage was used snowball sampling to select respondents, as the frame for sampling and the size of the sub-population of vanilla farmers in each municipality were not known. The distribution of respondents by municipality is shown in Table 1. The total sample size was 384 respondents as determined by equation (8). The sample was distributed in proportion to the number of households across each municipality, with 175 respondents in Ampohibe and 209 in Ambalabe.

Table 1: Sample size distribution of the respondents in the study area

Municipalities	**Number of households**	**Proportion**	**Sample size**
Ampohibe	4,093	45.49%	175
Ambalabe	4,905	54.51%	209
Total	**8,998**	**100%**	**384**

Source: INSTAT- CCER, 2018

3.6 Data Collection and Analysis

Primary data collection was conducted by surveying respondents and administering questionnaires in person to small-scale vanilla producers. A semi-structured questionnaire

was used to collect the primary data, which included both closed and open-ended questions. A pilot study was undertaken prior to the actual collection of data to test the reliability and validity of the questionnaire. The questionnaire was pre-tested with 40 small-scale vanilla producers in the Antalaha district, specifically in the municipality of Antalaha. The data collected has been analysed using principal component analysis, multivariate probit model, and gross margin analysis with an ESR. The software SPSS and STATA were employed to analyse the data.

3.7 Analytical Framework

The data collected was analysed in relation to the objectives.

3.7.1 Objective one: Vanilla market constraints among smallholder farmers in the Antalaha district, Madagascar

For this objective, Principal Component Analysis (PCA) was utilised. In this study, Factor Analysis (FA) was also considered suitable as it helps to condense large sets of variables into a smaller, more understandable set of components. It is widely used in social science research to uncover relationships between variables and to identify patterns in complex data (Balasundaram, 2009). According to Shrestha (2021), factor analysis identifies underlying dimensions that explain the correlations among observed variables so that researchers can focus on factors that explain for the most variation. Similarly, Guodaar and Asante (2018) note that FA minimises a big number of interrelated variables to a manageable number of common factors. PCA, in contrast, is specifically designed to lossless reduction of data dimensionality while preserving most of the original information (Muthui et *al.*, 2019).

Factor Analysis (FA) and Principal Component Analysis (PCA) have different main objectives. FA differs from PCA in that it seeks to identify a smaller number of factors that explain the shared variance among variables and addresses potential measurement errors, in order to give stable results (Costello & Osborne, 2005; Guodaar & Asante, 2018). In contrast, this research employed PCA, which was more appropriate to decrease data dimension and extract the key factors that affect the market constraints faced by smallholder vanilla farmers. The study employed PCA for grouping vanilla market constraints into clusters known as principal components. It was also be applied to the data set to find relationships between variables related to vanilla market constraints.

PCA is the most widely used multivariate statistical technique and is employed in almost all scientific disciplines (Abdi & Williams, 2010). PCA is a data reduction technique that decreases a complex data set to a simplified inferior dimension (Ermatita *et al.*, 2019).

PCA is also considered one of the most significant results of applied linear algebra and can be the first step in an attempt to analyse large data sets (Richardson, 2009).

Unlike FA, PCA is a major method for determining dominant groups in data sets using the eigenvalue and eigenvector techniques of matrix algebra. It also decomposes the covariant matrix's correlation into orthogonal eigenvalues and related eigenvectors (Otange, 2017). PCA computes a set of uncorrelated variables. These non-correlated components represent the overall original variance (Ouya *et al.*, 2019). The first principal components selected had the highest variation with the highest percentage of explained variance, indicating an indicator of quality of fit; the remaining elements with a small percentage of variance explained are removed (Cappellari & Jenkins, 2003; Ouya *et al.*, 2019).

In the following model, the methods were classified using principal component analysis. The clustered model is expressed as follows:

$Y_1 = a_{11}x_{12} + a_{12}x_2 + \ldots\ldots\ldots + a_{1n}x_n$

$Y_2 = a_{21}x_{21} + a_{22}x_2 + \ldots\ldots\ldots + a_{2n}x_n$ ..... (9)

.

$Y_j = a_{j1}x_{j1} + a_{j2}x_2 + \ldots\ldots\ldots + a_{jn}x_n$ ..... (10)

Where Y_1, Y_2, ……., Y_j = non-correlated principal components

$a_1 - a_n$= Correlation coefficient

x_1, …….., x_n= Factors that impact vanilla market constraints

In this research, the variables involved in the PCA were key market constraints faced by vanilla farmers, including lack of access to training, lack of access to resources (equipment, tools, etc.), poor road infrastructure, absence of financial access, absence of information (markets and price, etc), weak quality of vanilla, rainfall variability, political instability, government intervention, corruption, lack of transparency, existence of monopoly, pests (e.g., snails, slugs), and vanilla diseases.

The analytical hierarchy process (AHP) method is also suitable for this objective. AHP was proposed by Saaty in the 1970s, is very popular among multi-criteria decision-making methods (MCDM) and is especially suitable for the evaluation of socio-economic and management problems (Linkov & Moberg, 2011; Saaty, 1988; Subramanian & Ramanathan 2012). Additionally, AHP uses a MCDM, mainly qualitative, to evaluate local indicators by interviewing experts and applying priority scales (Kurek *et al.*, 2021). However, PCA was used for this objective, as it examined the indicators without losing any information, and to identify new, more significant variables in order to build a local model. Unlike AHP, PCA is

also a more quantitative decision-making tool. Further, AHP accommodates hypothesis development and subjective judgments, whereas PCA, through its strict statistical procedure, eliminates components that are not compatible with the underlying data structure (Palese, 2018).

3.7.2 Objective two: Factors influencing choice of different market outlets of vanilla among smallholder farmers in Antalaha district, Madagascar

This study employed a multivariate probit (MVP) model to examine the factors influencing smallholder farmers' selection of vanilla market outlets in the Antalaha district of Madagascar. Although both the multinomial logit (MNL) and ordered logit models could also be appropriate, given that the dependent variable has multiple outcomes, they present certain limitations. The MNL model, for instance, is most suitable when the decision-maker selects only one option from several mutually exclusive alternatives (Arumugam *et al.*, 2022; Tse, 1987). In contrast, smallholder vanilla farmers in this study often sell to more than one outlet simultaneously, making the choices non-mutually exclusive. Therefore, the MNL model was not appropriate. In addition, the assumption of independence of irrelevant alternatives (IIA) associated with the MNL model, that the relative probability of choosing one option is unaffected by the presence of others, further limits its applicability in this context (Vijverberg, 2011).

In addition, the ordered logit model, much like the multinomial logit model, is intended for cases where the dependent variable has an ordinal nature. However, this model was not appropriate for the current study because the marketing outlets available to smallholder farmers have no inherent order. Their choices are purely categorical and not ranked. This makes the ordered logit model unsuitable for analysis in this context.

The MVP model considers both the independence and correlation among farmers' choices of marketing channels. It is useful for analysing more than one outlet choice at a time (Arinloye et al., 2015; Ngenoh et al., 2020). In this study, the choice of market outlets by small-scale farmers is a multiple-response and is not mutually exclusive. This indicates that the MVP model fits well, as smallholder farmers might choose to sell their vanilla through local markets, urban markets, and cooperatives at the same time.

The econometric model is defined in terms of a vector of dependent Y_{it} which represent the outcomes of interest for the analysis. The MVP model's functional form is specified as follows:

$$Y_{it}^{*} = \beta_{it} X_{it} + \varepsilon_{it} \qquad \text{with } (t=1, 2, 3) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

where (t=1,2,3) represents the choice of the vanilla market outlets including local markets, urban markets and cooperatives, X_{it} is a 1× k vector of all factors that impact market outlet choice, β_{it} represents a k × 1 vector of the parameter to be estimated, ith farmer is given i(1,2,....,n) to choose a market outlet, and ε_{it} (t= 1,….,m) represents error terms.

The observed outcome for choosing the vanilla market outlet was modelled as follows,

Y_{it} [$\begin{matrix}1\ if\ Y_{it}^{*} > 0 \\ 0\ otherwise\end{matrix}$ t= 1, 2, 3; 0= otherwise

In this research, small-scale farmers choose market outlets based on their profits. Whereas, the decision of market outlet implies a multiple choice such as local markets, urban markets, and cooperatives. Consequently, the system of equations for each market outlet becomes:

$$Y_{1i}^{*} = \beta_1 X_1 + \varepsilon_{1i} \quad \text{(12)}$$

$$Y_{2i}^{*} = \beta_2 X_2 + \varepsilon_{2i} \quad \text{(13)}$$

$$Y_{3i}^{*} = \beta_3 X_3 + \varepsilon_{3i} \quad \text{(14)}$$

Where, Y_1^{*} =local market, Y_2^{*}= urban market, and Y_3^{*}= cooperatives.

The unknown parameters of equation (11) are estimated by simulated maximum likelihood. Consequently, the implicit functional form will be calculated to determine the factors which affect the decision of selecting market outlets by vanilla small-scale farmers will be given:

$$Y_i = \beta_0 + \beta_1 \text{Sex} + \beta_2 \text{Educ} + \beta_3 \text{Hhsize} + \beta_4 \text{Offinc} + \beta_5 \text{Lsize} + \beta_6 \text{LOwn} + \beta_7 \text{FarmExp} + \beta_8 \text{Group} + \beta_9 \text{VanYie} + \beta_{10} \text{Dry} + \beta_{11} \text{Green} + \beta_{12} \text{Dist} + \varepsilon_i \quad \text{(15)}$$

where, Y_i represents the market outlet choices by smallholder farmers.

β_0 is a constant, β_1 to β_{15} are coefficients and ε_i is the error term.

The description and measurement of the variables used in the MVP are presented in Table 2.

Table 2: Description and measurement of variables employed in multivariate probit model

Variables	Description	Unit of measurement	Expect sign
Dependent variables			
Market outlets	market outlets of vanilla (local markets, urban markets, and cooperatives)	Local markets, Yes=1;No=0 Urban markets, Yes=1;No=0, cooperatives, Yes=1;No=0	
Independent Variables			
Sex	Sex of smallholder farmers	Dummy, 0=female;1=male	+/-
Educ	Education level	Continuous (years)	+/-
Hhsize	Household size	Continuous (Number)	+/-
Offinc	Off-farm income	Dummy, yes=1, No=0	+/-
LSize	Land size	Continuous (hectares)	+/-
LOwn	Land ownership	Dummy, yes=1, No=0	+/-
FarmExp	Farmer's experience in Vanilla	continuous (years)	+/-
Group	Group membership	Dummy, yes=1, No=0	+/-
VanYie	Vanilla yield Produced/unit	Continuous (Kg)	+/-
Dry	Dry vanilla	Dummy, yes=1, No=0	+/-
Green	Green vanilla	Dummy, yes=1, No=0	+/-
Dist	Distance to the market	Continuous (km)	+/-

3.7.3 Objective three: Profitability of participation in different vanilla market outlets among smallholder farmers in the Antalaha district, Madagascar

Gross Margin Analysis (GMA) or Gross Profit Margin (GPM) was employed to determine this objective. Gross margin represents the difference between the revenue generated from product sales and the variable costs incurred in producing these products (Choumbou *et al.*, 2015; Kasonga, 2018). It is widely used in economic research to examine the profitability of farm production for both farmers and companies. In fact, gross margin is the most common indicator for evaluating the performance and profitability of a firm's main operations (Shi et al., 2021).

GMA has been widely accepted as an effective method of farm profitability because it is its simple to apply and accuracy (Kasonga, 2018). In addition, GMA allows comparison of profitability between of different farm activities and identification of ones generate the highest gross margins and profits (Popescu, 2012; Snezana *et al.*, 2013). GMA allows a company to make an analysis of the profitability of the productive activities. GMA is a

simple, practical method of measuring the financial performance of a business. GMA is an excellent tool for profitability analysis as it demonstrates how well-manage organisations can translate into sales profits (Vincent, 2021). GMA is an economic tool with several advantages as it allows the reasoning of technological and economic parameters to be easily accessed and implemented (Keru, 2021).

Gross margin is the distinction between the total amount of a company's production and the variable costs of the output

$$GM = TR - TVC \quad (16)$$

where, GM represents Gross Margin of smallholder vanilla farmers, TR represents Total (Gross) revenue, and TVC represents Total Variable costs.

The costs of Production are divided into fixed and variable costs. Variable costs of production was measured by determining the actual quantities of direct raw materials, direct labour as well as other variable inputs used in the production process, and multiplying these quantities by their respective unit costs (Hilton & Platt, 2015). Moreover, Variable cost is an agricultural expense that varies in proportion to the quantity produced by a farmer during a production season. Variable costs may increase or decrease depending on variations in the farm's output or sales volume, and they can rise if output increases and reduce if output falls. Further, the variable costs used to calculate profitability include weeding, transport, pollination, harvesting and processing. On the other hand, fixed production costs are costs that remain constant regardless of variations in production levels, and may include rent, depreciation and certain overheads (Garrison *et al.*, 2018; Horngren *et al.*, 2010).

Furthermore, variable costs are part of GM because they change in a short term or period. However, the gross margin does not use fixed costs, as these costs cannot change in a short period. Gross margin analysis cannot also include overheads or fixed costs including machine purchases, depreciation, permanent labour expenses, and comparison can be incorrect because fixed costs vary between different farms (Firth, 2002; Vincent, 2021). Additionally, the inclusion of fixed costs in the GMA may prevent the determination of the real profitability of products. GMA also excludes fixed and overhead costs as they are not directly linked to the production of specific products or services (Bragg, 2011).

Therefore, the gross margin was employed to analyse the profit of each vanilla market outlet. The GM was determined through the specified formula.

$$GM = \sum P_y Y - \sum P_x X \quad (17)$$

Where, $\sum P_y Y$= Total Revenue from vanilla.

$\sum P_x$X = Total costs incurred in producing vanilla.

P_y = Vanilla prices on the market outlets.

P_x= Inputs, labour and post-harvest costs supported by smallholder vanilla farmers.

Y = Quantity of vanilla produced and sold.

X = Quantity of each input used.

The gross margin is essential during and after the choice of outlets by small-scale vanilla farmers. The GM of a small-scale vanilla farmer was estimated based on the quantity provided for sale (kgs) during the last production season, the purchase price of vanilla stems, cost of inputs during production and after-harvest costs during and after the harvest. Additionally, the GM was calculated at the different vanilla market outlets. This information helped to identify which market outlets are profitable for smallholder farmers. Smallholder farmers should know how to choose the most suitable market outlet for their vanilla. If they are capable to select the most profitable market outlets, it is easy to make more profit from each harvest. Moreover, the estimation of the profitability provided by a market outlet is strongly impacted by the condition of the vanilla products before sale.

3.7.4 Objective four: Effect of market outlet choices on profitability among smallholder vanilla farmers in the Antalaha district, Madagascar

Endogenous switching regression (ESR) was employed to analyse the effect of market outlet choices on profitability for smallholder vanilla farmers. ESR model was preferred for this research because it effectively addresses the limitations of Ordinary Least Squares (OLS), Instrumental Variable (IV), and Heckman selection bias models (Ojo *et al.*, 2022). Heckman (1979) created a two-stage model to correct for selectivity bias by using the inverse Mills ratio from the first stage. However, Lokshin and Sajaia (2004) note that this method can cause heteroskedastic residuals, which makes it diffficult to estimate consistent errors.

By contrast, the ESR model considers for both endogeneity and sample selection bias, making it particularly suitable for the objectives of this research (Ojo *et al.*, 2022). In ESR model, a two-stage estimation method was used and conducted simultaneously (Di Falco *et al.*, 2011). The first stage was to estimate the probit model, which specified the factors influencing the choice of outlets:

$$Y_{ij}^{*} = X_{ij}\beta_i + \varepsilon_{ij} \text{ with } Y_{ij} \left[\begin{matrix} 1 \; if \; Y_{ij}^{*} > 0 \\ 0 \; otherwise \end{matrix} \right. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(18)}$$

Where: Y_i^* is the unobservable or latent variable for market outlets, X_i represents variables that affect market outlet choices, β represents the vector that represents of the parameter to be determined, α is the coefficient estimate, and ε_{ij} represents error terms.

In the second stage, the impact of different market outlets on farmers' gross margins was estimated. The model is specified for two regimes (Urban markets plus cooperatives and local markets):

Regime 1: $Y_{1i} = X_{1i}\beta_1 + \varepsilon_{1i}$ if $T_i = 1$ ……. (19a)

Regime 2: $Y_{0i} = X_{0i}\beta_0 + \varepsilon_{0i}$ if $T_i = 0$ ……. (19b)

Where Y_{ji} represents the dependents variable (Gross margin), X_{0i} and X_{1i} represent vectors of exogenous variables and β_0 , β_0 represent vectors of parameters. The assumption that ε_1 and ε_0 are evenly distributed with an average vector zero and a matrix of covariance

$$\Omega = \begin{bmatrix} \sigma_u^2 & \sigma_{1,u} & \sigma_{2,u} \\ \sigma_{1,u} & \sigma_1^2 & \sigma_{1,2} \\ \sigma_{2,u} & \sigma_{1,2} & \sigma_2^2 \end{bmatrix}$$

Where: σ_u^2 is the variation of the error term in the chosen equation, σ_1^2 and σ_2^2 represent variance of the error terms in the continuous equations. $\sigma_{1,u}$ represents a covariance of u_0 and ε_0 and $\sigma_{2,u}$ represents a covariance of u_1 and ε_1. Since both Y_{1i} and Y_{0i} do not appear simultaneously, the combined distribution of ε_1 and ε_0 is unable to identified. The assumption is that $\rho_{0,1}$=1.

The following conditional and unconditional expectations were calculated after estimating the model parameters. According to Lokshin & Sajaia (2004), these expectations are employed to assess the effect of the treatment.

Unconditional expectations:

E $(Y_{0i} | X_{0i}) = X_{0i}\beta_0$ …… (20a)

E $(Y_{1i} | X_{1i}) = X_{1i}\beta_1$ …… (20b)

Conditional expectations:

E $(Y_{0i} | I_i = 1, X_{0i}) = X_{0i}\beta_0 + \sigma_0\rho_0$ …….. (21a)

E $(Y_{0i} | I_i = 0, X_{0i}) = X_{0i}\beta_0 - \sigma_0\rho_0$ …….. (21b)

E $(Y_{1i} | I_i = 1, X_{1i}) = X_{1i}\beta_1 + \sigma_1\rho_1$ …….. (21c)

E $(Y_{1i} | I_i = 0, X_{1i}) = X_{1i}\beta_1 + \sigma_1\rho_1$ …….. (21d)

Moreover, the ESR model was employed to examine the Average Treatment Effect on the Treated (ATT) and the Average Treatment Effect on the Untreated (ATU) by comparing the expected outcomes of choosing urban markets plus cooperatives with those of local markets (counterfactuals). Carter and Milon (2005), the ATT was calculated using the following equations:

Actual scenario (urban markets plus cooperatives):

$$\left.\begin{array}{l} E(Q_{1i}|I = 1) = Z_i\alpha_1 + \sigma_i \lambda_1 \\ E(Q_{0i}|I = 1) = Z_i\alpha_0 + \sigma_i \lambda_0 \end{array}\right\} \ldots\ldots (22)$$

Counterfactual (local markets):

$$\left.\begin{array}{l} E(Q_{0i}|I = 0) = Z_i\alpha_1 + \sigma_1 \lambda_0 \\ E(Q_{1i}|I = 0) = Z_i\alpha_1 + \sigma_1 \lambda_1 \end{array}\right\} \ldots\ldots (23)$$

The expected results are utilised to obtain unbiased estimations of the ATT.

$$ATT = E(Q_{1i}|I = 1) - E(Q_{0i}|I) = 1) = Z_i\ (\alpha_1 - \alpha_0 + \lambda_i(\sigma_1 - \sigma_0)\ \ldots\ldots (24a)$$

Similarly, the ATU for farmers who sell in local markets was determined as:

$$ATU = E(Q_{1i}|I = 0) - E(Q_{0i}|I = 0) = Z_i\ \ (\alpha_1 - \alpha_0 + \lambda_i(\sigma_1 - \sigma_0)\ \ldots\ldots (24b)$$

This model is additionally applicable to determine the effects of heterogeneity (HE), which can be presented as follows;

$$BH_1 = E(Q_{1i}|I = 1) - E(Q_{1i}|I = 0) \ldots\ldots (25a)$$

$$BH_o = E(Q_{0i}|I = 1) - E(Q_{0i}|I = 0) \ldots\ldots (25b)$$

Where BH_1 and BH_o reflect the base heterogeneity impact of gross margin for farmers who sell to urban markets plus cooperatives and those who sell to local markets. It is important to note that transitional heterogeneity can be determined by taking the difference between ATT and ATU.

$$TH = ATT - ATU = [E(Q_{1i}|I = 1) - E(Q_{0i}|I) = 1] - [E(Q_{1i}|I = 0) - E(Q_{0i}|I = 0)].(26)$$

The description and measurement of the variables utilized ESR estimation model are shown in Table 3.

Table 3: Description and measurement of variables used in the Endogenous Switching Regression (ESR) estimation model

Variables	Description	Unit of measurement	Expect sign
Dependent variable			
GM	Gross margin	Continuous (Ariary)	
Independent Variables			
Sex	Sex of smallholder farmers	Dummy, 0=female;1=male	+/-
Educ	Education level	Continuous (years)	+/-
Hhsize	Household size	Continuous (Number)	+/-
Offinc	Off-farm income	Dummy, yes=1, No=0	+/-
LSize	Land size	Continuous (hectares)	+/-
LOwn	Land ownership	Dummy, yes=1, No=0	+/-
FarmExp	Farmer's experience in Vanilla	continuous (years)	+/-
Group	Group membership	Dummy, yes=1, No=0	+/-
VanYie	Vanilla yield Produced/unit	Continuous (Kg)	+/-
Dry	Dry vanilla	Dummy, yes=1, No=0	+/-
Green	Green vanilla	Dummy, yes=1, No=0	+/-
Training	Agricultural training	Dummy, yes=1, No=0	+/-
Dist	Distance to the market	Continuous (km)	+/-

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter provides the results and discussions of the outcomes of the research. It discusses and describes the results from descriptive statistics, principal component analysis, multivariate probit model, GMA, and ESR, all aligned with the objectives of the research.

4.2 Socio-demographic and Economic characteristics of Vanilla Farmers in Antalaha district, Madagascar

The findings in Table 4 below show socio-demographic factors of vanilla farmers in Antalaha district of Madagascar. The mean age of participants was around 45 years. This productive age means that they are in an active and productive phase, enabling them to manage their farms effectively and implement modern farming techniques. On average, the majority of respondents had around 6 years of formal education, which shows a low level of literacy among vanilla farmers. This would limit their exposure to modern farming knowledge and reduce the ability of farmers to adopt better practices. This has a negative effect on production efficiency and output. Smallholder vanilla farmers had, on average, 14 years of experience with high farm experience in vanilla farming. This experience would definitely help them deal with vanilla farming problems and make fully informed practice decisions. The households averaged four members, which is crucial labour for farming activities. Having several members can relieve labour bottlenecks, raise productivity and general farm efficiency.

Table 4: Socio-demographic attributes of vanilla farmers in Antalaha district

Variables	Mean (N=384)	Std. Dev.
Age (years)	44.76	14.53
Education (schooling years)	6.02	3.63
Farming experience (Years)	13.66	11.16
Household size	4.30	1.86

The economic factors of vanilla farmers in Antalaha district of Madagascar are presented in Table 5. The average of the respondents was around 1 hectare of land. Vanilla agroforestry systems prevail for most of the SAVA region's farmland, according to Hänke (2020), occupying a mean of 0.9 ha/farm, followed by rice (0.6 ha), coffee (0.1 ha), cocoa (0.1 ha), and cloves (0.1 ha). This is a reflection of the significance of vanilla, especially in Antalaha, where it forms the core activity in livelihood among many smallholder farmers.

The study also showed that the vanilla per hectare yield is 46 kg on average. All this low productivity emanates from the frequent incidence of vanilla diseases (*Bekorontsana*), inefficient farm practices, and inefficient access to quality inputs. In addition, poor extension services, uncertainty in the weather, and shortfalls in the market further constrain farmers in achieving sustainable yields.

Table 5: Economic factors of vanilla farmers in Antalaha district, Madagascar

Variables	**Mean (N=384)**	**Std. Dev.**
Land size (hectares)	1.38	1.17
Vanilla yield (Kg)	46.27	64.71

Table 6 presents the results for sex, land ownership, agricultural training, and group membership among vanilla farmers. Most of the vanilla farmers in the research were men out of 93% of the total, while only 7% were women. This was because men easily accessed resources, capital, and information needed for vanilla cultivation. In term of land ownership, 72% of farmers owned formal titles to their land, giving them stronger greater security and stability, which can be used to finance agriculture practices and long-term planning. In terms of community participation, only 20% of the farmers belonged to community institutions, indicative of minimal cooperation among vanilla growers. Low group membership can restrict access to collective resources, skills, and advice, thereby affecting general productivity and farm resilience. As far as agricultural training, the findings reveal that 16% of the farmers are adequately trained. This implies that only group members can easily access training compared to those working alone. The data show that 34% of farmers sell dry vanilla, whereas 83% sell green vanilla. This indicates that the majority of smallholder vanilla farmers in Madagascar prefer to sell green vanilla because it gives them quicker income and is easier to process than dry vanilla, which takes more time, effort, and skills to dry before selling.

Table 6: Distribution of sex, land ownership, agricultural training, group membership, dry, and green vanilla among vanilla farmers

Variables		**Percentage (%)**
Sex	Male	93.2
	Female	6.8
Landownership	Yes	72.4
	No	27.6
Training	Yes	16.2
	No	83.8
Group membership	Yes	20.3
	No	79.7
Dry vanilla	Yes	34.1
	No	65.9
Green vanilla	Yes	83.3
	No	16.7

Table 7 shows that the majority of farmers (80%) sold their vanilla on the local markets, followed by cooperatives (21%), and the urban markets (5%) respectively. This means that most of vanilla farmers distribute their products in local markets. Although the local markets offers relatively low prices, it remains the preferred choice for 80% of vanilla farmers because of its proximity to their farms and the facility it offers for quick and accessible sales. These findings are in line with those of Adugna *et al.* (2019) and Olufadewa and Obi-Egbedi (2018) who reported that the majority of small-scale farmers choose to sell their products on the local market.

Table 7: Preference for different market outlets among vanilla farmers

Variables	**Frequency**	**Percentage (%)**
Local markets	307	80
Urban markets	18	4.7
Cooperatives	81	21.1

4.3 Vanilla Market Constraints among Smallholder Farmers

This objective aimed to unveil the vanilla market constraints among smallholder vanilla farmers in two municipalities in the Antalaha districts of Madagascar. PCA was

utilised to explain the greatest proportion of total variation. The first section of this objective shows the combinations and descriptions of vanilla market constraints that select the datasets explaining a greater proportion of the total variability in Ampohibe and Ambalabe. The study focused on 14 constraints in the vanilla market and participants were required to evaluate the severity of the constraints on three scales including mild (1), severe (2) and very severe (3).

Table 8 presents descriptive statistics on the composition of each component of vanilla market constraints. PCA was used to reduce and group the principal component into four vanilla market constraints. The first principal component was market and resource issues, which encompassed lack of access to training, lack of access to resources, poor road infrastructure, lack of financial access and lack of information (prices, markets, etc.). The second principal component was the governance challenges which included political instability, intervention by the government, corruption, lack of transparency and existence monopoly. The third principal component was farm risk, namely pests (snails, slugs, etc.) and vanilla disease. Finally, the fourth principal component was environmental challenges associated with low vanilla quality and rainfall variability. Moreover, the first principal component had an average of 2.01 and a standard deviation of 0.34. The second and third principal components have a mean of 2.94 and a standard deviation of 0.18 and 0.26 respectively. The last principal component had an average of 2.79 and a standard deviation of 0.32.

Table 8: Combinations and descriptions of vanilla market constraints

Group	Mean	Std. dev.	Constraints
Component 1: Market and resource issues	2.01	0.34	Lack of access to training Lack of access to resources Poor road infrastructure Lack of financial access Absence of information (price, markets, etc.)
Component 2: Governance challenges	2.94	0.18	Political instability Intervention by the government Corruption Lack of transparency Existence monopoly
Component 3: Farm risk	2.94	0.26	Pests (snails, slugs, etc.) Vanilla disease
Component 4: Environmental challenges	2.79	0.32	Weak quality of vanilla Rainfall variability

Table 9 shows four components, namely market and resource issues, governance challenges, agricultural risks, and environmental challenges. The first component represents 33.08% of the variance. The second and third principal components represent 21.11% and 10.29% of the variation respectively. Finally, the fourth principal component represents 8.01% of the variation. The other components have been dropped due to their inability to justify fewer variations in the data.

Table 9: Results for screened farmers based on eigenvalues

Component	Eigenvalue	Proportion (%)	Cumulative (%)
Comp1	**4.6310**	33.08	33.08
Comp2	**2.9556**	21.11	54.19
Comp3	**1.4405**	10.29	64.48
Comp4	**1.1218**	8.01	72.49
Comp5	0.7575	5.41	77.90
Comp6	0.7987	5.06	82.96
Comp7	0.6907	4.93	87.90
Comp8	0.5884	4.20	92.10
Comp9	0.4211	3.01	95.11
Comp10	0.3115	2.23	97.33
Comp11	0.2644	1.89	99.22
Comp12	0.0799	0.57	99.79
Comp13	0.0188	0.13	99.93
Comp14	0.0101	0.07	100

Note: Comp = component

This research used the Scree Plot to select the number of principal components. The objective for employing PCA is to minimise the data set and use only eigenvalues that are equal or greater than to one. Figure 3 shows a Scree plot with the principal component numbers on the x-axis and the eigenvalues on the y-axis. The point at where the slope passes through a steep slope to a gentle slope provides the principal component number to be determined in the analysis. The steep slope components were selected, converting the initial set of 14 constraints in a smaller set of 4 linear compositions known as principal components. The other components were eliminated because they provided only a tiny explanation for the variation in the variables of origin.

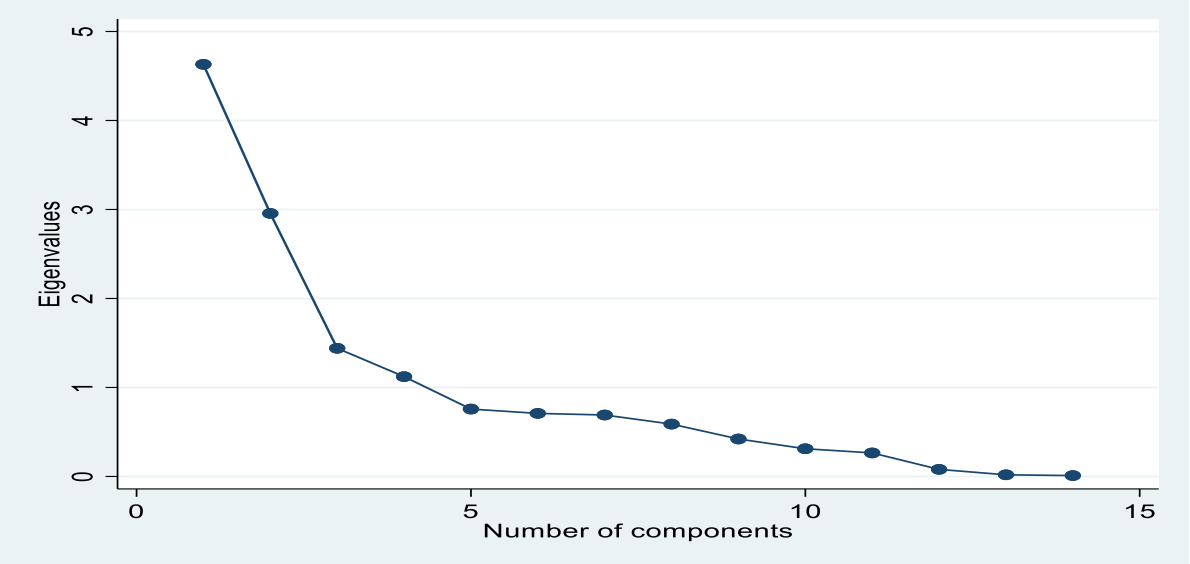

Figure 3: Scree plot of eigenvalues

The components were rotated orthogonally (varimax method) (Chatterjee *et al.*, 2015; Wekesa *et al.*, 2018) to minimise highly correlated constraints, which facilitates interpretation and generalisation within a group. According to Kaiser (1958), with eigenvalues greater than 1, the finding of the rotation was 4 principal components out of the 14 possible. The four components include: firstly, lack of access to communication, infrastructure, finance, and the market; secondly, political and policy challenges; thirdly, diseases and pests; and finally, product attributes and rainfall variability. To evaluate the sample size suitable for analysis, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of spherical were employed. The value of 0.799 ($p < 0.001$) shows that the sample was well-fitted for PCA, since values above 0.70 are usually considered (Kaiser, 1974). Additionally, Goni et al. (2020), the sample is deemed adequate if the KMO is greater than 0.5 and Bartlett's test is significant ($P < 0.001$). Table 10 presents the component loadings of the factors that affect vanilla market constraints. The components of each constraint are shown in bold.

Table 10: Components loading for the determinants of vanilla market constraints

Variables	Comp1	Comp2	Comp3	Comp4	Unexplained
Lack of access to training	**0.4557**	-0.0081	-0.0058	0.0221	0.0368
Lack of access to resources	**0.4390**	0.0114	-0.0017	0.0109	0.1070
Poor road infrastructure	**0.4350**	0.0086	0.0192	-0.0292	0.1247
Lack of financial access	**0.4526**	0.0031	0.0106	-0.0105	0.0524
Absence of information (price, markets, etc.)	**0.4496**	-0.0083	-0.0061	0.0232	0.0619
Weak quality of vanilla	0.0295	-0.0484	-0.1008	**0.7599**	0.2934
Rainfall variability	-0.0469	0.0892	0.1277	**0.6209**	0.4148
Political instability	0.0078	**0.4095**	-0.0679	-0.0791	0.5173
Intervention by government	-0.0059	**0.4169**	-0.0310	-0.0982	0.5054
Corruption	0.0023	**0.4903**	-0.0544	0.0105	0.2957
Lack of transparency	-0.0013	**0.4664**	0.1624	0.1207	0.2734
Existence monopoly	0.0030	**0.4350**	-0.0443	-0.0114	0.4509
Pests (snails, slugs, etc.	0.0120	0.0135	**0.6923**	-0.0617	0.3483
Vanilla disease	-0.0082	-0.0222	**0.6759**	0.0193	0.3691
Eigen value	4.6310	2.9556	1.4405	1.1218	
Proportion (%)	33.08	0.2111	0.1029	0.0801	
Cumulative (%)	33.08	0.5419	0.6448	0.7249	

Bartlett's sphericity test:

Chi-square = 4862.297

Degrees of freedom = 91

P-value = 0.000

Kaiser-Meyer-Olkin (KMO) sampling suitability measure = 0.799

The results shows that market and resource issues such as limited access to training, resources, financial services, information, and poor road infrastructure, and governance challenges, including political instability, government intervention, corruption, lack of transparency, and monopolistic practices, are the major impediments to farmers' access to markets. These are followed by farm risks, such as diseases and pests, and environmental challenges, including low vanilla quality and rainfall variability. The results show that variables have higher loadings when they are strongly correlated with a specific underlying component that captures the common variance between related variables. On the other hand,

variables with lower loadings are either weakly correlated with the components extracted or have a more unique and unexplained variance.

4.4 Determinants of Choice of Different Market Outlets among Vanilla Farmers

To examine the factors affecting smallholder vanilla farmers' selection of market outlets, a multivariate probit (MVP) model was employed. Prior to estimating the model, the data were tested for multicollinearity and heteroscedasticity to address potential specification issues.

4.4.1 Multicollinearity test

A multicollinearity test was conducted on the predictor variables to identify any correlation issues among the independent variables. Multicollinearity occurs when some predictors in a regression model are highly correlated with each other. The Variance Inflation Factor (VIF) was used to assess the degree of correlation between the explanatory variables. The results, presented in Table 11, show that all VIF values are below 10, indicating no multicollinearity among the continuous explanatory variables. According to Gujarati (2003), a VIF greater than 10 would suggest a multicollinearity problem. Further, the rule of thumb indicates that if the average values of the VIF are higher than 10, it indicates multicollinearity.

Table 11: Variable inflation factor for the explanatory variables

Continuous variables	**VIF**	**1/VIF**
Dry vanilla	2.26	0.442
Green vanilla	1.78	0.562
Log vanilla yield	1.78	0.563
Faming experience	1.34	0.747
Land size	1.30	0.767
Education	1.29	0.777
Group membership	1.27	0.785
Land ownership	1.16	0.863
Distance to the market	1.14	0.879
Receive off- income	1.10	0.910
Sex	1.08	0.921
Household size	1.07	0.936
Mean VIF	**1.38**	

Pairwise correlations were computed to ensure that multicollinearity was not a concern among the independent categorical variables. As shown in Appendix D, the correlations indicate that no strong linear relationships exist between the predictors. This is due to the fact that the pairwise correlation for all variables is less than 0.75, which constitutes a threshold (Gujarati, 2003). This allows them to run regression models to analyse the factors that impact vanilla producers' access to market outlets.

4.4.2 Test for heteroscedasticity

The Breusch-Pagan and White heteroscedasticity tests were also employed to examine the association between the variance of the disturbance term and the independent variables without supposing any specific relationship.

The Breusch-Pagan/Cook-Weisberg test was conducted to check for heteroscedasticity in the regression model. The results (prob > chi2 = 0.000) indicated the presence of heteroscedasticity in the OLS model. As a result, the null hypothesis of homoscedasticity was rejected at both the 90% and 95% significance levels, showing that the residuals were not uniform. Following Stock and Watson (2008), robust standard errors were applied to correct for the heteroscedasticity issue.

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

H0: Constant variance

Chi2 (1) = 804.72

Prob > chi2 = 0.000

In addition, to address the econometric problem of heteroscedasticity, the White test was also employed and the findings are shown in Table 12 with a p-value of 0.000, which is less than the 5% level of significance. This shows the existence of heteroscedasticity, which means that the variance of the error terms is not constant between observations. To solve this, robust standard errors were included in the analysis to solve the problem of heteroscedasticity.

Table 12: White test of heteroskedasticity

Source	Chi2	Df	p-value
Heteroscedasticity	166.16	83	0.0000
Skewness	29.39	12	0.0034
Kurtosis	1.95	1	0.1621
Total	197.50	96	0.0000

4.4.3 Factors influencing choice of market outlets

The findings of the multivariate probit model on factors affecting the choice of market outlets among vanilla farmers are shown in Table 13 The results reveal the Wald test (Wald chi2 (36) = 576.93, p<000) and the likelihood ratio test (LR Chi2 (3) = 100.935, p<0.000). The covariance matrix, designated rho21=rho31=rho=32=0, indicates that the rho are significantly statistically significant at the 95 per cent confidence level. This implies that the null hypothesis, which supposes that all rho values are jointly equal to zero, is rejected. This indicates that the MVP had a high explanatory power and was well fitted.

Table 13: Multivariate probit results for factors influencing choice of different market outlets among smallholder vanilla farmers

Variables	Local markets			Urban markets			Cooperatives		
	Coef.	Robust Std. err.	P>z	Coef.	Robust Std. err.	P>z	Coef.	Robust Std. Err.	P>z
Sex (1=Male,0=Female)	-0.051	0.434	0.906	3.599	0.730	0.000***	0.160	0.437	0.714
Education (schooling years)	-0.041	0.027	0.129	0.051	0.046	0.264	0.053	0.024	0.031**
Household Size (Number)	-0.005	0.046	0.905	0.106	0.087	0.223	0.032	0.044	0.469
Off- farm income (Yes, No)	-0.030	0.203	0.881	0.963	0.435	0.027**	0.107	0.176	0.546
Land size (hectares)	-0.045	0.081	0.579	-0.004	0.132	0.974	0.029	0.090	0.750
Land ownership (Yes, No)	0.124	0.191	0.515	-0.630	0.379	0.096*	-0.043	0.237	0.857
Farming experience (Years)	0.009	0.010	0.387	0.009	0.014	0.512	0.001	0.009	0.901
Group membership (Yes, No)	-1.99	0.231	0.000***	0.166	0.312	0.594	1.833	0.231	0.000***
Log vanilla yield (Kg)	-0.127	0.091	0.163	0.444	0.175	0.011**	0.148	0.084	0.079*
Distance to the market (Km)	0.013	0.009	0.160	-0.019	0.015	0.221	-0.011	0.010	0.259
Dry vanilla	0.229	0.263	0.383	4.740	0.437	0.000***	0.386	0.273	0.156
Green vanilla	0.596	0.296	0.044**	-0.231	0.317	0.466	0.534	0.299	0.075*
Constant	1.178	0.655	0.072	-12.004	1.480	0.000	-2.833	0.655	0.000

Number of observations: 384, Wald chi2 (36) = 576.93, Log pseudolikelihood = -222.203,
Prob > chi2 =0.0000, rho21 = rho31 = rho32 = 0.
The asterisk ***, ** and * Represents 1%, 5%, and 10% significant levels, respectively.

Results in Table 13 show that sex, education, off- farm income, land ownership, group membership, vanilla yield, dry vanilla and green vanilla significantly affect the market outlet choices. For the local markets, group membership was significant at 1% level, and green vanilla was significant with a level of 5%. Sex, and dry vanilla were significant at the 1% level, vanilla yield and receive off-income were significant at the 5% level, and land ownership was significant at the 10% level in the urban markets. For the cooperatives, group membership was significant at the 1% level, education was significant at the 5% level, and vanilla yield and dry vanilla were significant at the 10% level.

Sex has a significant and positive effect, with male being much more probably to sell their vanilla in urban markets at a 1% significance level. In fact, men are about 360% more likely than women to choose urban markets, likely because these markets offer higher vanilla prices compared to local markets or cooperatives. Men also tend to have better access to transportation, making it easier for them to transport their vanilla to urban centers. Supporting these findings, Hänke *et al.* (2018) reported that women are less integrated into the vanilla value chain, whereas men-headed households benefit from higher sales and better contract completion rates in Madagascar. Similarly, Endris *et al.* (2020) reported that men farmers in Ethiopia were more likely to market onions to collectors than women. Ngeno *et al.* (2024) also showed that male farmers were more likely than women to sell carrots in the local market.

Education has a positive effect on the choice of cooperatives, at 5% significance level. This means that formal education increases the probability of selecting cooperatives by 5.3%. Educated farmers become more aware of the benefits of cooperatives, like reasonable prices, raise market access, and services, that can help them survival in unstable markets. Amato (2018) notes that vanilla farmers frequently from cooperatives in order to have access zero-interest loans, bargain prices collectively, get better prices for their product, and obtain greater security against theft of their. Similarly, Hänke *et al.* (2018) found that highly educated households have bigger fields and greater experience in vanilla farming, which increases their market in urban areas. The findings are parallel to Degefa *et al.* (2022), which reported that education improves the profitability of selecting cooperative outlets in Ethiopia. Chekol and Mazengia (2022) also confirmed that more schooling enable farmers to make better choices about market sales on the consideration of trade margins and marketing costs.

Off-farm income has a positive effect on the likelihood of farmers selling to urban markets, which is significant at 5% level. Farmers with non-agricultural income are much

more likely (96.3%) to reach urban markets than non-farm income farmers due to the ease of coverage of transport expenses and availability of extra resources to travel and negociate better prices. Off-farm income earns additional revenue, and farmers are able to sell in urban market. These findings differ from those of Gachoka *et al.* (2023), Ng'ang'a *et al.* (2022), and Ermias and Yildiz (2021), who concluded that off-farm income had a negative effect on farmers' choices for brokers, wholesalers, or retail markets. These results contradict because the farmers sell vanilla, whereas in other studies, the farmers plant mangoes and beans, which have different market options and price. Additionally, perishable commodities such as mangoes have a higher chance of spoiling within a short duration, and thus farmers can opt to sell through middlemen or wholesalers rather than the urban market.

Land ownership has a significant negative effect on sales in the urban market, with a level of 10%. Vanilla producers who are own land are 63% less likely to sell in urban markets. Many landowners diversify and produce other crops which are an option source of income in case of unexpected events, compared to those who utilize family/communal land. A result, they are not compelled to make long journeys into remote urban markets, because they have other ways to make a living. Additionally, land ownership improves the production capacity of farmers, leading agricultural productivity, as it provides right security and access to resources that are available (Mdoda & Gidi, 2023). The results oppose Momanyi (2016), which showed that ownership of land positively influenced the probability of farmers accessing in market at 5% significant level. The inconsistency is because the results of Momanyi (2016) focus on vegetable farmers, who may experience different market dynamics compared to vanilla farmers. Additionally, vegetable production often requires quick sales due to the perishability of the crops, leading farmers to prioritize immediate market access.

Group membership has a negative and positive significant impact on the choice of selecting the local market and cooperative market at 1% level respectively. Being a cooperative or farmers' group member reduces the chances of selling on the local market and increases the choice of selling to cooperatives. The reason for this could be that the cooperative offers technical support and training to its members and distributes a bonus each year. The findings are in agreement with those of Tarekegn *et al.* (2017), who revealed cooperative membership positively and significantly impacted the likelihood of selecting a cooperative outlet. They also revealed a negative and significant impact of selecting collector's outlet at 5% level. Further, the study by Chelang'a *et al.* (2023) revealed that membership of a farm group negatively impacted the choice of intermediaries and spot combinations.

The vanilla yield produced (quantity of vanilla produced) significantly and positively impacts urban market choice at the 5% level. Vanilla yield increases the likelihood of farmers selling through cooperative outlets, significant at the 10% level. Farmers who produce more vanilla can sell in urban markets and cooperatives rather than local markets This means these outlet possess a greater volumes. This aligns with Kotey *et al.* (2021), who showed that the quantity sold of cowpea positively influenced the likelihood of selecting wholesale markets at 1% level. Similarly, Ermias and Yildiz (2021) found that larger quantities affected farmers' decisions of wholesalers and collectors at 1% and 10% significance levels.

Dry increases the probability of farmers selling in urban markets at 1% significance. Dry vanilla is preferred by farmers for selling in urban markets compared cooperatives or local markets because it has a longer life, better transport, and premium prices. Dry vanilla beans generally get better prices than fresh or green vanilla, which makes them more profitable. The results align with Peña-Barrientos et al. (2023), who revealed that dried vanilla beans command premium prices due to their enhanced flavour, making them more desirable in foreign markets.

Green vanilla has a positive effect on farmers' sales in local markets (5% level) and cooperatives (10% level). Local markets and cooperatives are the most favoured outlets for farmers with green vanilla because of the direct connection to buyers, saving transport cost and time. In addition, local markets and cooperatives are able to offer better prices for green vanilla due to more connections with buyers and the bargaining power of cooperatives. The results are in line with those of Watteyn *et al.* (2022) who found that the majority of farmers favour the sale of green vanilla pods compared to dried vanilla due to lowered processing costs and faster profits.

4.7 Gross Margin for Different Vanilla Market Outlets

Gross Margin Analysis (GMA) was employed to examine the profitability of participating in different vanilla market outlets.

4.7.1 T-test for gross margin on market outlets

Table 14 shows that farmers who sell on the local markets have a gross margin of 4396.90 Ariary per Kg, while farmers who decide to sell on the urban markets and cooperatives have a gross margin of 6206.12 Ariary per kg. The results show that farmers who sell on the local markets have a lower gross margin than those who choose other market outlets.

Table 14 shows that farmers who sell in local markets have a gross margin of 4396.90 Ariary per kg. In contrast, farmers who sell in urban markets and cooperatives have a gross margin of 6206.12 Ariary per kg. The findings indicate that farmers in local markets earn less gross margin than those using other market outlets.

Table 14: Gross margin of farmers choosing local markets over urban markets and cooperatives (Local Markets=1 and others=0)

Variables	**Local markets (N=307)**	**Urban market and cooperatives N(=77)**	**t-test**	**p-value**
Gross margin (Ariary per kg)	4396.90	6206.12	1.385	0.1667

Note: 1$USD=4 500 Ariary

Table 15 shows that farmers who sell on cooperatives have a gross margin of 5351.24 Ariary per kg, while farmers who decide to sell on the local and urban markets have a gross margin of 4601.55 Ariary per kg. The results show that farmers who sell on cooperatives have a higher gross margin than those who choose other markets (local and urban markets).

Table 15: Gross margin of farmers choosing cooperatives over Local and urban markets (Cooperatives=1 and others=0)

Variables	**Cooperatives (N=81)**	**Local and urban markets N(=303)**	**t-test**	**p-value**
Gross margin (Ariary per kg)	5351.24	4601. 55	-0.584	0.560

Note: 1$USD=4 500 Ariary

Table 16 shows that farmers who sell on urban markets have a gross margin of 7458.25 Ariary per kg, while farmers who decide to sell on the local markets and cooperatives (other markets) have a gross margin of 4626.97 Ariary per kg. The results show that farmers who sell on urban markets have a higher gross margin than those who choose other markets (local and cooperatives).

Table 16: Gross margin of farmers choosing urban markets over Local and cooperatives (Urban markets=1 and others=0)

Variables	**Urban markets (N=18)**	**Local and markets and cooperatives N(=366)**	**t-test**	**p-value**
Gross margin	7458.25	4626.97	-1.143	0.254

(Ariary per kg)				

Note: 1$USD=4 500 Ariary

4.8 Effect of Market Outlet Choices on Profitability

4.8.1 Gross margin of farmers choosing urban markets and cooperatives compared to local markets

Table 17 shows that farmers who sell on urban markets and cooperatives (other markets) have a gross margin of 6089.68 Ariary per kg, while farmers who decide to sell on the local markets have a gross margin of 4340.65 Ariary per kg. The results show that farmers who sell on urban markets and cooperatives have a higher gross margin than those who choose local markets.

Table 17: Gross margin of farmers choosing urban and cooperative market outlets over local markets (urban markets plus cooperatives=1 and local market =0)

Variables	**Urban and cooperatives (N= 92)**	**Local markets N(=292)**	**t-test**	**p-value**
Gross margin (Ariary per kg)	6089.68	4340.65	-1.428	0.154

Note: 1$USD=4 500 Ariary

Comparing the choice of market outlets, it seems that selling in urban markets and cooperatives allows farmers to make higher profits than selling in local markets.

4.8.2 Estimation of effect of market outlets on gross margin

ESR model was employed to analyze the gross margins of vanilla farmers across different market outlets. Based on the data, urban markets and cooperatives are combined in this analysis because the number of farmers selling in these markets is fewer than in local markets. The outcome equations for gross margin among smallholder vanilla farmers who sold in urban markets plus cooperatives and in local markets were jointly estimated with the selection equation for the decision to sell in market outlets. Diagnostic tests showed the coefficient estimated for the two instrumental variables (education and agricultural training) were jointly insignificant (F2, 371, p-value=0.2353) in the outcome (gross margin) equation. Both instrumental variables showed significant effects in the market outlet decision equation and appropriate for identifying the gross margin equation, as they did not directly affect the gross margin of vanilla farmers. The Wald test [$\chi 2$ (10) = 28.52; $p < 0.001$] indicated the joint significance of the instruments, thus rejecting the null assumption of weak instruments. The

findings of the endogenous switching regression model estimation on the effects market outlet choices on gross margin among smallholder vanilla farmers are presented in Table 18.

Table 18: Endogenous switching regression results for the effect of market outlet choices on gross margin

Variables	Selection equation			Urban markets and cooperatives=1 Gross margin			Local markets=0 Gross margin		
	Coef.	Std. err.	P>z	Coef.	Std. err.	P>z	Coef.	Std. err.	P>z
Sex (1=Male,0=Female)	0.053	0.347	0.880	12148.200	4356.642	0.005***	-1949.516	2440.450	0.424
Household Size (Number)	0.059	0.047	0.205	221.027	589.180	0.708	13.522	327.859	0.967
Off- farm income (Yes, No)	0.262	0.193	0.176	-3496.246	2205.988	0.113	-335.427	1333.929	0.801
Land size (hectares)	0.010	0.073	0.896	-1555.112	791.354	0.049**	-670.997	625.675	0.284
Land ownership (Yes, No)	-0.221	0.200	0.268	1149.517	2514.645	0.648	-1290.457	1422.017	0.364
Farming experience (Years)	0.003	0.008	0.718	-35.669	98.098	0.716	9.502	58.940	0.872
Distance to the market (Km)	-0.015	0.009	0.089*	-149.1846	100.806	0.139	-72.421	66.710	0.278
Log vanilla yield (Kg)	0.276	0.083	0.001***	-1985.802	1139.572	0.081*	1298.346	572.826	0.023**
Green vanilla	0.116	0.242	0.632	-4276.313	2568.367	0.096*	-2358.701	2390.594	0.324
Dry vanilla	0.503	0.226	0.026**	2037.43	2649.635	0.442	1865.617	2097.45	0.374
Training (Yes, No)	1.094	0.248	0.000***						
Education (schooling years)	0.016	0.024	0.048**						
Constant	-2.249	0.557	0.000***	20301.35	7075.404	0.004***	9175.171	4300.798	0.033**
σ				10099.620	1074.91	0.000***	10397.61	482.213	0.000***
ρ				-0.800	0.108	0.000***	0.407	0.142	0.001***
LR test for independent Equations: Rho 1 =rho 0, chi2=6.46, Prob >chi2 = 0.011**									

Note: ***, **, and * represent significance at a 1%, 5% and 10% significance level, respectively.

Table 18, in its first column, shows the results of the selection equation, indicating the factors that influence farmers' choice of market outlets. Distance to the market, vanilla yield, training, and education significantly influence the choice of market outlets for vanilla producers. Columns 2 and 3 present the findings of the outcome equations (gross margin) for urban markets and cooperatives, and for local markets, respectively. To clearly identify the model, the instrumental variables (training and education) in the market outlet choice (Probit model) were left out of the gross margin equation. Diagnostic tests showed that these instrumental variables affected only the choice of market outlet and did not directly influence the gross margin.

Sex has a positive influences gross margin in urban markets and cooperatives at 1% significance level. The results show that male farmers earn more from sales in these outlets compared to female farmers. Men have better access to information on the market, higher mobility, and stronger bargaining power, which helps them capture higher prices. The results are consistent with Pyburn et al. (2023), who noted that men take part more in profit value chains with high capital investment, while women are more involved in domestic and informal markets. Similarly, the World Bank (2024) reports that Malagasy women have restricted access to good jobs and are more likely to be involved in subsistence farming. This entails to lower incomes and lesser access to profitability markets.

Land size has a negative relationship with urban market and cooperative gross margin at 5% significance level. This means that farmers who have more land have less profit per hectare than farmers who have small plots of land. Large farms might practice diversification of crops or have greater labour and management expenses, thus lower efficiency in the production of vanilla. These findings are in agreement with Celio et al. (2023), which showed that northeast Madagascar's large landholdings were correlated with improved income vulnerability given the market uncertainty and climatic risk. Similarly, Hänke et al. (2018) determined that in the SAVA region, larger farms have diversified production, which can offset the concentration and specialization in vanilla and its profitability.

Distance to the market has a negative influence on farmers' market participation at 10 % level of significance, and it affects gross margin. Farmers who are farther from markets likely to earn lower profits because they have greater transportation costs and logistical complications. Buckmaster (2012) supports that improving access to markets and transaction costs reduction are very vital to rural incomes increase and agricultural profitability improvement.

Vanilla yield has a positive and significant effect on farmers' participation in market outlet. Its impact on gross margins is significant at 1% level Further, higher vanilla yields lead increase gross margins in local markets at 5% level. Farmers with larger yields are more active in market outlets and have higher profits. Higher production not only provides an overage to be sold but also enhances farmers' bargaining power and market opportunities. This indicates that productivity growth encourages market participation and increases profitability, and it underlines the economic importance of yield gains in the vanilla sector. However, in urban markets and cooperatives, higher yields were associated with lower gross margins at the 10% significance level. This may be due to oversupply causing prices to go down or additional processing and marketing costs in cooperatives diminishing the benefits of larger yields (Marcos-Matás *et al.*, 2013). This is what Barrett (2008) reported, where increased agricultural production can actually reduce farm-gate prices and margins when markets are poorly integrated or there are high transaction costs.

Green vanilla was associated with decreased gross margins in urban markets and cooperatives, and the impact was at 10% level. Selling green vanilla is less profitable for farmers. Lower prices for green vanilla, and higher processing as well as marketing costs in cooperatives, are to blame for these lower margins. The majority of Malagasy farmers, for instance, market green vanilla from the farm at very low prices, which undermines their income (Fairtrade Foundation, 2024). Similarly, Giovannucci and Ponte (2005) note that poor processing and quality control along value chains can reduce farmers' profits, particularly when the products are sold in raw form.

Dry vanilla had a negative impact on profits across market outlets at 5% significance level. The negative effect of dry vanilla on gross margins means that farmers who sell it may experience a loss of profits. This is because of the high process and storage costs and price instability, which generally stop farmers from getting the best value for their produce. Further, quality standards and buyer requirements can reduce smallholders' bargaining power, diminishing their profits despite selling a product with higher added value. According to Neilson (2008), the vanilla value chain in Madagascar is characterised by significant control exercised by buyers and strict quality requirements, which limits farmers' ability to profit from dry vanilla, which has a higher value. Similarly, Fairfood International (2020) reports that despite the high value of dry vanilla, farmers frequently receive a minimal proportion of the final price due to the complex nature of the value chain and the predominance of intermediaries.

The last two lines of the ESR in Table 18 indicate the correlation coefficients estimated ρ for urban markets, cooperatives, and local markets in vanilla market outlets, and both are not statistically different from zero. Consequently, even though this was not known a priori, it indicated that the zero assumption of no bias in sampling could not be eliminated. As predicted, the findings in the final two columns of Table 18 (outcome equations) indicate that numerous factors significantly affect the gross margin of the choice of market outlets. It was found that sex positively and significantly influences the gross margin of vanilla per kg in urban markets and cooperatives. Vanilla yield negatively and positively significant influenced on the gross margin of vanilla in urban markets, cooperatives, and local markets. Furthermore, land size and green vanilla negatively and significantly influence the gross margin of vanilla farmers in urban markets and cooperatives.

Table 19 shows the effect of market outlets on gross margin for small-scale vanilla farmers who sell on Urban and cooperatives (other markets) rather than local markets in the Antalaha district.

Table 19: Mean treatment effect of market outlets on gross margin (urban markets and cooperatives=1, local markets =0)

Market outlets	**Decisions stage**		**ATE**	**t-test**	**p-value**
	Urban markets and cooperatives (N=92)	**Local markets (N=292)**			
Urban markets and cooperatives (N=92)	a) 6086.08	b) 7715.77	ATT= -1629.68	-2.739	0.007***
Local markets (N=292)	c) 6303.84	d) 4340.60	ATU=1963.24	8.098	0.000***
Heterogeneity effects	-217.76	3375.17	TH = -3592.92		

***: significant at 1%.

Note: ATE refers to the Average Treatment Effect, ATT to the Average Treatment Effect on the Treated, ATU to the Average Treatment Effect on the Untreated, and TH stands for Transitional Heterogeneity.

In cells (a) and (d), the values represent the average gross margins earned in other markets and in the local market. However, cells (b) and (c) indicate the counterfactual values

to be expected. The ATT is obtained by subtracting the value in (b) from that in (a). The ATT results show that vanilla farmers who choose other markets (urban markets plus cooperatives) would earn 1 629.68 Ariary less per kg if they had chosen the local market. The results for the ATU represent the difference between (c) and (d), which means that those selling in local market would earn 1 963.24 Ariary per kg if they decided to choose the other markets (urban markets plus cooperatives). The results show that other market outlets significantly and positively impact on gross margin for both actual and counterfactual. This implies that for each decision stage, farmers who sell on other markets achieve higher gross margins than those who sell on local markets.

The last row of the table indicates the potential heterogeneity effects between other markets (urban markets and cooperatives) and local markets for vanilla farmers. If the local markets had decided to sell on other markets (urban markets and cooperatives), they would be expected to earn a higher gross margin of 217.76 Ariary per kg than the current vanilla farmers who have chosen other markets. Column (2) indicates that farmers who choose other markets would earn a higher gross margin of 3,375.17 Ariary per kg compared to farmers who choose local markets, even if they did not sell in the markets. The transitional heterogeneity (TH) indicates that the impact of market outlets on gross margin was significantly greater for farmers selling in local markets compared to those selling in other markets. This implies that farmers who sell on the local market would earn 3592.92 Ariary per kg higher than those who sell on other markets.

The results show that vanilla farmers should sell their products in urban markets and cooperatives rather than in local market, as the market outlets have a greater gross margin than local market. This is because cooperatives provide beneficial prices through collective bargaining and they offer give supporting services, including training and finance that raise productivity and livelihoods. Moreover, urban markets are more favourable prices, access to the market for more consumers, less relationship on middlemen, and contract farming opportunities, which improved farmers' profit. However, based on the research undertaken by Keru (2021), direct sales outlet stakeholders were found to earn more profits for coffee farmers among all other market outlets. Inconsistency is in the fact that vanilla farmers get higher gross margins from cooperatives and urban markets while the highest returns for coffee farmers are through direct sales outlets. The reason also is that farmers sell different crops, each having different market forces, cost profiles, logistical challenges, and economic conditions that vary across country.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter describes the conclusions and the recommendations.

5.2 Conclusions

The overall objective of this research was to contribute to improved livelihoods of smallholder vanilla farmers in Antalaha district of Madagascar through an understanding of the choice of market outlets for enhanced profitability. The specific objectives of the study were to examine vanilla market constraints among smallholder farmers, to determine factors influencing choice of different market outlets of vanilla among smallholder farmers, and to determine the profitability of participation in different vanilla market outlets among smallholder farmers in the Antalaha district of Madagascar. To achieve these objectives, primary data was captured using a semi-structured questionnaire. The conclusion from the study regarding each of the objectives are presented below;

i. Smallholder vanilla farmers in the Antalaha district face significant market constraints, that can be categorized under four major areas: market and resource issues, governance problems, farm risk, and environmental challenges. It is essential to address the challenges to enhance farmers' access to markets and profitability.

ii. The major factors that influence smallholder vanilla farmers' choice of market outlets are gender, education, off-farm income, land ownership, group membership, vanilla yield, green vanilla, and dry vanilla. Understanding these factors can help create programs that support farmers in making better marketing choices and increasing their participation in the market.

iii. Selling vanilla through cooperatives and urban markets improves gross margins for smallholder vanilla farmers compared to local markets. Encouraging farmers to utilize these more lucrative outlets can lead to improved livelihoods and economic sustainability.

iv. The effect of market outlet choices on smallholder vanilla farmers' gross margin showed that distance to market, vanilla yield, dry vanilla, training, and education are the major determinants of the market outlet choice of farmers. Gross margin comparison between actual and counterfactual scenarios showed that vanilla yield had a uniform impact on profitability across the two groups. Male farmers realized higher gross margins in urban markets and cooperatives, while green vanilla and larger land

sizes reduced the profits. Overall, farmers would get more income from selling in urban markets and cooperatives than from selling in local markets. The counterfactual analysis showed that those who usually sell in local markets would be in a position to increase their gross margins if they changed their selling to urban markets or cooperatives.

5.3 Recommendations

The findings of the study provide the following recommendations:

i. The government should help small-scale vanilla farmers with improved market infrastructure, simpler access to market information, and increased transparency. Government policies should also address financial assistance, quality standards training, and pest, disease, and climate risk management programs to increase productivity and profits. Smallholder farmers should group into cooperatives or farm groups to increase bargaining power, share resources for better quality, receive quality market information, and struggle for transparency and equitable pricing.

ii. The government should enhance education, expand the availability of market and agricultural training, and infrastructure to allow smallholder vanilla farmers to transcend market challenges and make value sales. Policymakers should also intervene further to stabilise prices, improve transparency in market operations, and enhance cooperatives, which enable the farmer to have sustainable ways of selling his produce.

iii. Farmers should focus on selling their produce through cooperatives and urban markets in order to earn better gross margins and improve their livelihoods. The government should invest in infrastructure, market access initiatives and cooperative development to help farmers improve their profitability.

iv. The policymakers should invest in rural market access and infrastructure. This will cut the distance to cooperative and urban markets, which can easily increase farmers' gross margins. Further, smallholder farmers should also boost vanilla yields and ensure proper post-harvest handling of green and dry vanilla. This will increase gross margins and profitability.

5.4 Further Research

Further research should be done on the effect of global market trends and price fluctuations on the marketing strategies of smallholder vanilla farmers, focusing on the implications for the development of policies and interventions. Additionally, according to the study, group membership seemed to strongly influence choice, therefore assessing the role of

social networks and farmer organisations on the market outlet choices used by smallholder farmers requires an in-depth research.

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APPENDICES

Appendix A: Research Questionnaire

Dear Sir/Madam

My name is **Georgia RAHELISON**, I am doing MSc degree in Agricultural and Applied Economics at Egerton University, Kenya. I am doing my research on "**Effect of Choice of Market Outlets on Profitability among Vanilla Smallholder Farmers in Antalaha District, Madagascar**". This study is purely academic in nature. I kindly request your participation in this interview, as the information you give me will help me to achieve the objectives of my study. I guarantee that the information provided will remain strictly anonymous, private, and confidential for this research project. Your participation will be greatly appreciated.

Thank you in advance for your participation.

Georgia Rahelison

Contact: +261328488642 / +254742403903

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FARMERS SURVEY QUESTIONNAIRE

Section A. General Information

A1. Questionnaire number ……

A2. Date of interview ……/…../2024

A3. Name of enumerator ……

A4. Is respondent the head of household: 1=Yes [ ] 0= No [ ]

A5. Municipality …….

A6. Fokontany …….

Section B. Socio-economic Information on Farmers

B1. Age of smallholder vanilla farmer ? (Years) …….

B2. Gender of smallholder vanilla farmer:

1= Male ☐ 0= Female ☐

B3. What is the education level of smallholder vanilla farmer? (Schooling years) ……..

B4: How many people usually live in the household? (*Including non-biological members*) ……..

B5. Are you involved in any other on-farm activities?

1=Yes ☐ 0=No ☐

B6. Are you involved in other activities unrelated to farming?

1=Yes ☐ 0=No ☐

Source of income	**Amount**
1. Off-farm	
2. Vanilla income	
3. Agricultural Income from farm produce sales (milk, livestock, cassava, Bananas, etc)	
Total household income	

B7. What was the estimated amount of income for the year (2023)? (In Ariary)

B8. What is your other occupation?

1. Civil servant/ employee ☐
2. Self-employed ☐
3. Other(s) specify ……

B9. What are the main sources of household income?

1. Off-farm ☐
2. Vanilla income ☐
3. Agricultural and livestock ☐

Section C: Farm Characteristics/Vanilla production

C1. How many hectares of land do you use for vanilla cultivation? (Hectares)……

C2. Do you own this land?

1=Yes ☐ 0=No ☐

C3. If yes, what type of land ownership do you have?

With title ☐ Communal land ☐ Leased Own ☐

C4. How many years have you been cultivating vanilla? .....years

C5. Do you grow vanilla under contract? 1=Yes ☐ 0=No ☐

C6. Was your vanilla harvest what you expected last year? 1=Yes ☐ 0=No ☐

C7. If not, what factors contributed to the low vanilla yields last year

(1) ……..

(2) ……..

(3) …….

(4) ……..

C8. Do you have regular contact with the extension services?

1=Yes ☐ 0=No ☐

C9. If yes, indicate the number of times you have been in contact with extension officers in the last year ……

C10. Have you been trained in vanilla production practices?

1=Yes ☐ 0= No ☐

C11. If yes, indicate the area of training you have taken.……

C12. How many training have you taken in the last year?

………
……

C13. Who trained you last year?

……..

C14. On average, how many kilograms of vanilla yield did you produce last year?..... (Kg)

C15. What form of vanilla have you sold?

1. Green vanilla ☐
2. Dry vanilla ☐
3. Both ☐

C16. On average, how many kilograms of vanilla have you sold last year? (Kg)

Forms of vanilla	**Quantity of vanilla sold last year (in Kg)**
Green vanilla	
Dry vanilla	
Total quantity of vanilla sold	

C17. What are your variable costs in vanilla production and how much you spend on them last year?

Variable cost	**Yes**	**No**	**Cost per hectare/ year**
Thinning or weeding			
Transports			
Fertilizers			
Pesticides			
Pollination			
Harvesting			
Processing			
Other (specify)			

Section D: Vanilla Marketing/Institutional Factors

D1. What is the distance to the market? (Km) …….

D2. In your opinion, what is the state of the road between the farm and the market?

1. Good ☐ 2. Average ☐ 3. Bad ☐

D3. Indicate the mode of transport use to deliver the product to the selected market outlet

Mode of transport	Tick the appropriate choice	Cost of transport (in Ariary)
1. Hand carrying/Carry on shoulder		
2. Bicycle		
3. Motorbike		
4. Cart		
5. Car		
6. Canoe		

D4. Is the transport hired or privately owned by the farmer?

1. Hired ☐ 2. Owned ☐

D5. Are you a member of any vanilla farmer group/association?

1=Yes ☐ 0= No ☐

D6. If yes, indicate the name of the group/association?

……
…….……
……

D7. What is the main objective of your group/association?

……
……
……

D8. What benefits do you get from the group/ association?

……
……
……

……
…

D9. Do you have market information before selling the farm produce? (E.g. Price, markets, etc.) 1=Yes ☐ 0=No ☐

D10. Where did you get your market information?

1. Radio ☐
2. Television ☐
3. Buyers ☐
4. Mouth to mouth ☐
5. Group/association ☐
6. Government/Extension services ☐
7. Other (specify)

……

D11. How do you rate obtaining vanilla market information?

1. Very easy ☐ 2. Easy ☐ 3. Difficult ☐ 4. Very difficult ☐

D12. Do you store any of the vanilla produced?

1=Yes ☐ 0=No ☐

D13. If yes, indicate the quantity stored during the previous year's harvest (2023). (Kg)

…….

D14. Indicate the main reason for storage

1. For future sales ☐
2. Other (specify) …….

D15. Do you treat your vanilla before storage?

1=Yes ☐ 0=No ☐

D16. If yes, indicate the treatment used

……
……
…….

D17. Which market outlet did you sell your green vanilla?

Market outlets	**Tick appropriate choice**	**Price per Kg of green vanilla (in Ariary)**	**Quantity of output (per year)**	**Total revenue**
1. Local markets				
2. Urban markets				
3. Cooperatives				

D18. Why did you choose this or these market outlet(s)?

……
…….

D19. Which market outlet did you sell your dry vanilla?

Market outlets	**Tick appropriate choice**	**Price per Kg of dry vanilla (in Ariary)**	**Quantity of output (per year)**	**Total revenue**
1. Local markets				
2. Urban markets				
3. Cooperatives				

D20. Why did you choose this or these market outlet(s)?

………
.

D21. Which mode of selling did you use?

1. Cash ☐ 2.Credit ☐ 3.Both ☐

D22. Who are the main buyers of your vanilla?

1. Local collectors/brokers ☐
2. traders ☐
3. Processors ☐
4. Exporters ☐
5. Cooperatives ☐
6. Other (specify)…….

D23. Did you obtain credit to manage your vanilla farming activity last year?

1=Yes ☐ 0= No ☐

D24. If yes, indicate the sources and the total amount you received (2023)

Source	**Total amount (in Ariary)**	**Annual interest paid**
Bank		
Cooperatives society		
Farm group		
Other (specify)		

Section E. Vanilla Market Constraints

E1. Have you experienced problems in your vanilla market?

1=Yes ☐ 0=No ☐

E2. If yes, what problems have you encountered?

Constraints	**Yes**	**No**	**Severity of constraints**
Lack access to training			1=Mild, 2=severe, 3=Very severe
Lack access to resources (equipment, tools, etc.)			1=Mild, 2=severe, 3=Very severe
Poor road infrastructure			1=Mild, 2=severe, 3=Very severe
Lack of financial access			1=Mild, 2=severe, 3=Very severe
Absence of information (price, markets, etc.)			1=Mild, 2=severe, 3=Very severe
Weak quality of vanilla			1=Mild, 2=severe, 3=Very severe
Rainfall variability			1=Mild, 2=severe, 3=Very severe
Political Instability			1=Mild, 2=severe, 3=Very severe
Intervention by government			1=Mild, 2=severe, 3=Very severe
Corruption			1=Mild, 2=severe, 3Very severe
Lack of transparency			1=Mild, 2=severe, 3=Very severe
Existence monopoly			1=Mild, 2=severe, 3=Very severe
Pest (snails, slugs)			1=Mild, 2=severe, 3=Very severe
Vanilla disease			1=Mild, 2=severe, 3=Very severe

E3. Kindly share any other problems concerning

1. The production of vanilla
   ……
   ……
   ……
   ……
2. The marketing of vanilla……

Appendix B: Ethical Clearance

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EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

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Approval No. EUISERC/APP/343/2024 ***12th June* 2024**

Georgia Rahelison
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Egerton- Njoro, Kenya
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Dear Georgia,

RE: ETHICAL APPROVAL: EFFECT OF CHOICE OF MARKET OUTLETS ON PROFITABILITY AMONG VANILLA SMALLHOLDER FARMERS IN ANTALAHA DISTRICT, MADAGASCAR

This is to inform you that the ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/343/2024.*** The approval period is 12th ***June 2024 – 13th June 2025***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours.
v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to ***Egerton University Institutional Scientific and Ethics Review Committee***.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

EGERTON UNIVERSITY
Date. 12/06/2024
RESEARCH ETHICS

Yours sincerely.

Prof. Raphael M. Ngure

CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE

RMN/BK/

Appendix C: Research Permit

REPOBLIKAN'I MADAGASIKARA
Fitiavana - Tanindrazana - Fandrosoana

MINISTERE DE L'AGRICULTURE ET DE L'ELEVAGE

SECRETARIAT GENERAL

DIRECTION REGIONALE DE L'AGRICULTURE ET DE L'ELEVAGE
SAVA

AUTORISATION DE MISSION N° : 080 /2024/MINAE/SG/DRAE.SAVA

Il est autorisé à Madame RAHELISON Georgia, étudiante à l'université de Kenya, de se rendre dans Le District d'Antalaha, pour l'étude de l'effet du choix des points de vente sur la rentabilité des petits exploitants de vanille dans ce dit district pour une durée de jours à partir de 29 Juin 2024.

Cette autorisation lui est délivrée pour servir et valoir partout où besoin sera.

Sambava, le 28/06/2024

Le Directeur Régional de l'Agriculture et de l'Elevage
P/O Le Chef de Service Régional de l'Agriculture

DIRECTION REGIONALE DE L'AGRICULTURE DE L'ELEVAGE
SAVA

BELALAHY Canut Dieudonné

Appendix D: STATA Results

Multicollinearity tests Stata output

- Vif

```
    Variable |       VIF       1/VIF
-------------+----------------------
         Dry |      2.26    0.441602
       Green |      1.78    0.561584
lnvanillay~d |      1.78    0.562740
  Experience |      1.34    0.746594
    Landsize |      1.30    0.766829
   Education |      1.29    0.777486
Groupmembe~p |      1.27    0.785384
Landowners~p |      1.16    0.863113
        Dist |      1.14    0.878699
Receiveoff~e |      1.10    0.909995
      Gender |      1.08    0.921802
      hhsize |      1.07    0.930562
-------------+----------------------
    Mean VIF |      1.38
```

```
hettest
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of Vanincome_
H0: Constant variance
    chi2(1) = 804.72
Prob > chi2 = 0.0000

White's test
White's test
H0: Homoskedasticity
Ha: Unrestricted heteroskedasticity
   chi2(83) = 166.16
Prob > chi2 = 0.0000
Cameron & Trivedi's decomposition of IM-test
```

```
-------------------------------------------------
              Source |       chi2     df         p
---------------------+---------------------------
  Heteroskedasticity |     166.16     83    0.0000
            Skewness |      29.39     12    0.0034
            Kurtosis |       1.95      1    0.1621
---------------------+---------------------------
               Total |     197.50     96    0.0000
```

- pairwise correlation

```
corr Gender Education hhsize Receiveoffincome Landsize Landownership Experience
Groupmembership lnvanillayield Dist Dry Green
```

(obs=384)

```
             |     Gender  Educat~n     hhsize  Receiv~e  Landsize  Landow~p  Experi~e  Groupm~p
lnvani~d
-------------+------------------------------------------------------------------------------
-
      Gender |   1.0000
   Education |   0.0904   1.0000
      hhsize |   0.1604  -0.0667   1.0000
Receiveoff~e |  -0.0028   0.2416   0.0330   1.0000
    Landsize |   0.1090  -0.0063   0.0602  -0.0035   1.0000
Landowners~p |  -0.0505  -0.0877   0.0556  -0.0644   0.1799   1.0000
  Experience |  -0.0733  -0.2952   0.1183  -0.1360   0.1813   0.2961   1.0000
Groupmembe~p |  -0.0185   0.0432   0.1066  -0.0227   0.2223   0.0367   0.1391   1.0000
lnvanillay~d |    0.0706    0.0375    0.0918   -0.0546    0.4510    0.1666    0.2699    0.3855
1.0000
        Dist |    0.1126    0.1702    0.0780   -0.0706   -0.0445   -0.1132    0.0425   -0.1098   -
0.0700
         Dry |    0.1065    0.1394    0.0584    0.0348    0.2283    0.1617    0.1614    0.2784
0.5053
       Green |   -0.0927   -0.1784   -0.0294   -0.0754   -0.0432   -0.0886   -0.0043   -0.0174   -
0.2203

             |     Dist      Dry    Green
-------------+---------------------------
        Dist |   1.0000
         Dry |   0.0012   1.0000
       Green |   0.0517  -0.6215   1.0000
```

- Multivariate Probit

```
mvprobit ( Local= Gender Education hhsize Receiveoffincome Landsize Landownership
Experience Groupmembership lnvanillayield Dist Dry Green) (Urban= Gender Education
hhsize Rec
> eiveoffincome Landsize Landownership Experience Groupmembership lnvanillayield
Dist Dry Green) (Coop= Gender Education hhsize Receiveoffincome Landsize
Landownership Experienc
> e Groupmembership lnvanillayield Dist Dry Green), robust

Iteration 0:   log pseudolikelihood = -284.69122
Iteration 1:   log pseudolikelihood = -238.72838
Iteration 2:   log pseudolikelihood = -225.84504
Iteration 3:   log pseudolikelihood = -222.78566
Iteration 4:   log pseudolikelihood = -222.29355
Iteration 5:   log pseudolikelihood = -222.21898
Iteration 6:   log pseudolikelihood =  -222.2052
Iteration 7:   log pseudolikelihood = -222.20339
Iteration 8:   log pseudolikelihood = -222.20304
Iteration 9:   log pseudolikelihood = -222.20297
Iteration 10:  log pseudolikelihood = -222.20295
```

```
Multivariate probit (MSL, # draws = 5)             Number of obs   =        384
                                                   Wald chi2(36)   =     576.93
Log pseudolikelihood = -222.20295                  Prob > chi2     =     0.0000
------------------------------------------------------------------------------
                |               Robust
                | Coefficient  std. err.      z    P>|z|     [95% conf. interval]
----------------+-------------------------------------------------------------
Local           |
         Gender |  -.0510433   .4344322    -0.12   0.906    -.9025148    .8004281
      Education |   -.040738   .0268253    -1.52   0.129    -.0933145    .0118385
         hhsize |  -.0054533   .0456892    -0.12   0.905    -.0950025    .0840958
Receiveoffincome |  -.0304513   .2034137    -0.15   0.881    -.4291347    .3682322
        Landsize |  -.0447075   .0805709    -0.55   0.579    -.2026235    .1132085
   Landownership |   .1241596   .1906034     0.65   0.515    -.2494161    .4977354
      Experience |   .0088439   .0102222     0.87   0.387    -.0111912     .028879
 Groupmembership |  -1.992149   .2310238    -8.62   0.000    -2.444947   -1.539351
  lnvanillayield |  -.1269762   .0909385    -1.40   0.163    -.3052124    .0512601
            Dist |   .0128015   .0091076     1.41   0.160     -.005049    .0306521
             Dry |   .2288559   .2625248     0.87   0.383    -.2856832     .743395
           Green |   .5956291   .2955154     2.02   0.044     .0164296    1.174829
           _cons |   1.178299   .6552842     1.80   0.072    -.1060343    2.462633
----------------+-------------------------------------------------------------
Urban           |
         Gender |   3.599244   .7295479     4.93   0.000     2.169356    5.029131
      Education |   .0512774   .0459141     1.12   0.264    -.0387125    .1412673
         hhsize |    .105528    .086664     1.22   0.223    -.0643303    .2753863
Receiveoffincome |   .9631434     .43475     2.22   0.027     .1110491    1.815238
        Landsize |   -.004359   .1321971    -0.03   0.974    -.2634606    .2547426
   Landownership |  -.6300668   .3787471    -1.66   0.096    -1.372397    .1122639
      Experience |   .0094469   .0143971     0.66   0.512     -.018771    .0376648
 Groupmembership |   .1662526   .3120098     0.53   0.594    -.4452755    .7777806
  lnvanillayield |   .4438683   .1753448     2.53   0.011     .1001988    .7875377
            Dist |   -.018757   .0153227    -1.22   0.221     -.048789    .0112751
             Dry |   4.740376   .4369207    10.85   0.000     3.884027    5.596724
           Green |  -.2313969   .3172676    -0.73   0.466    -.8532299    .3904362
           _cons |  -12.00403   1.479566    -8.11   0.000    -14.90393   -9.104139
----------------+-------------------------------------------------------------
Coop            |
         Gender |    .160297   .4366022     0.37   0.714    -.6954276    1.016022
      Education |   .0526008   .0244232     2.15   0.031     .0047323    .1004693
         hhsize |   .0315244   .0435006     0.72   0.469    -.0537352    .1167839
Receiveoffincome |   .1065624   .1763004     0.60   0.546    -.2389801    .4521048
        Landsize |   .0285515   .0895221     0.32   0.750    -.1469085    .2040115
   Landownership |  -.0426677   .2372729    -0.18   0.857     -.507714    .4223787
      Experience |     .00118   .0094438     0.12   0.901    -.0173294    .0196894
 Groupmembership |   1.832877    .230659     7.95   0.000     1.380794     2.28496
  lnvanillayield |   .1478951   .0841964     1.76   0.079    -.0171268    .3129169
            Dist |  -.0114243   .0101212    -1.13   0.259    -.0312615    .0084129
             Dry |   .3862862   .2726197     1.42   0.156    -.1480385    .9206109
```

```
           Green |   .5335792   .2994275     1.78   0.075    -.0532879    1.120446
           _cons |  -2.832934   .6547209    -4.33   0.000    -4.116164   -1.549705
-----------------+------------------------------------------------------------------
    /atrho21 |  -.5349025   .1594279    -3.36   0.001    -.8473754   -.2224296
-------------+------------------------------------------------------------------
    /atrho31 |   -1.39883   .1856606    -7.53   0.000    -1.762718   -1.034942
-------------+------------------------------------------------------------------
    /atrho32 |   .4774942   .1612249     2.96   0.003     .1614991    .7934893
-------------+------------------------------------------------------------------
       rho21 |  -.4891197   .1212867    -4.03   0.000    -.6896958   -.2188325
-------------+------------------------------------------------------------------
       rho31 |  -.8850986   .0402142   -22.01   0.000    -.9428058    -.775883
-------------+------------------------------------------------------------------
       rho32 |   .4442345   .1294081     3.43   0.001     .1601095    .6603812
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
            chi2(3) =  100.935   Prob > chi2 = 0.0000
```

- Gross margin
- Correlation matrix

```
corr  Gender  hhsize  Receiveoffincome  Landsize  Landownership  Experience  Dist
lnvanillayield Green
> Dry Training Education
(obs=384)

             |    Gender    hhsize  Receiv~e  Landsize  Landow~p  Experi~e       Dist
lnvani~d    Green
-------------+------------------------------------------------------------------------
------------
      Gender |   1.0000
      hhsize |   0.1604   1.0000
Receiveoff~e |  -0.0028   0.0330   1.0000
    Landsize |   0.1090   0.0602  -0.0035   1.0000
Landowners~p |  -0.0505   0.0556  -0.0644   0.1799   1.0000
  Experience |  -0.0733   0.1183  -0.1360   0.1813   0.2961   1.0000
        Dist |   0.1126   0.0780  -0.0706  -0.0445  -0.1132   0.0425   1.0000
lnvanillay~d |    0.0706    0.0918   -0.0546    0.4510    0.1666    0.2699   -0.0700
1.0000
       Green |  -0.0927   -0.0294   -0.0754   -0.0432   -0.0886   -0.0043    0.0517   -
0.2203   1.0000
         Dry |    0.1065    0.0584    0.0348    0.2283    0.1617    0.1614    0.0012
0.5053  -0.6215
    Training |  -0.0508    0.0549   -0.0401    0.1825    0.0335    0.1226   -0.0835
0.3480  -0.0506
   Education |    0.0904   -0.0667    0.2416   -0.0063   -0.0877   -0.2952    0.1702
0.0375  -0.1784

             |      Dry Training Educat~n
```

```
-------------+----------------------------
         Dry |   1.0000
    Training |   0.2067   1.0000
   Education |   0.1394   0.0538   1.0000
```

- ESR

```
movestay GMperkg Gender hhsize Receiveoffincome Landsize Landownership Experience
Dist lnvanillayield Green Dry, select ( UrCoopLo = Training Education )

Fitting initial values .....
Iteration 0:  Log likelihood = -4214.0448
Iteration 1:  Log likelihood = -4212.8555
Iteration 2:  Log likelihood = -4212.0183
Iteration 3:  Log likelihood = -4211.9142
Iteration 4:  Log likelihood = -4211.9136
Iteration 5:  Log likelihood = -4211.9136

Endogenous switching regression model             Number of obs   =        384
                                                  Wald chi2(10)   =      28.52
Log likelihood = -4211.9136                       Prob > chi2     =     0.0015

------------------------------------------------------------------------------
                 | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-----------------+------------------------------------------------------------
GMperkg_1        |
          Gender |    12148.2   4356.642     2.79   0.005     3609.342    20687.07
          hhsize |   221.0272   589.1796     0.38   0.708    -933.7435    1375.798
Receiveoffincome |  -3496.246   2205.988    -1.58   0.113    -7819.903    827.4115
        Landsize |  -1555.112   791.3544    -1.97   0.049    -3106.138   -4.086114
   Landownership |   1149.517   2514.645     0.46   0.648    -3779.096    6078.129
      Experience |  -35.66933   98.09798    -0.36   0.716    -227.9378    156.5992
            Dist |  -149.1846   100.8057    -1.48   0.139    -346.7601    48.39092
  lnvanillayield |  -1985.802   1139.572    -1.74   0.081    -4219.321    247.7174
           Green |  -4276.313   2568.367    -1.66   0.096    -9310.219    757.5932
             Dry |    2037.43   2649.635     0.77   0.442     -3155.76    7230.619
           _cons |   20301.35   7075.404     2.87   0.004     6433.814    34168.89
GMperkg_0        |
          Gender |  -1949.516    2440.45    -0.80   0.424    -6732.709    2833.677
          hhsize |   13.52192    327.859     0.04   0.967    -629.0699    656.1138
Receiveoffincome |  -335.4268   1333.929    -0.25   0.801     -2949.88    2279.027
        Landsize |  -670.9972   625.6749    -1.07   0.284    -1897.298     555.303
   Landownership |  -1290.457   1422.017    -0.91   0.364    -4077.558    1496.645
      Experience |   9.501538   58.94032     0.16   0.872    -106.0194    125.0224
            Dist |  -72.42129   66.70968    -1.09   0.278    -203.1699    58.32728
  lnvanillayield |   1298.346    572.826     2.27   0.023     175.6275    2421.064
           Green |  -2358.701   2390.594    -0.99   0.324    -7044.179    2326.776
             Dry |   1865.617    2097.45     0.89   0.374    -2245.309    5976.544
           _cons |   9175.171   4300.798     2.13   0.033     745.7621    17604.58
-----------------+------------------------------------------------------------
UrCoopLo         |
          Gender |   .0526053   .3470095     0.15   0.880    -.6275209    .7327315
          hhsize |   .0594564   .0468766     1.27   0.205    -.0324201    .1513328
Receiveoffincome |   .2616152   .1933108     1.35   0.176     -.117267    .6404974
        Landsize |   .0095385   .0728155     0.13   0.896    -.1331772    .1522542
   Landownership |  -.2210847   .1997131    -1.11   0.268    -.6125152    .1703457
      Experience |   .0029742   .0082246     0.36   0.718    -.0131457    .0190941
            Dist |  -.0147907   .0087035    -1.70   0.089    -.0318493    .0022679
  lnvanillayield |   .2759589   .0833591     3.31   0.001     .1125781    .4393396
           Green |   .1160665   .2420803     0.48   0.632    -.3584022    .5905351
             Dry |     .50316   .2264164     2.22   0.026      .059392     .946928
        Training |   1.093548   .2481066     4.41   0.000     .6072681    1.579828
       Education |   .0164801   .0237405     0.69   0.048    -.0300504    .0630106
           _cons |  -2.249456   .5568684    -4.04   0.000    -3.340898   -1.158014
-----------------+------------------------------------------------------------
       /lns1 |   9.220253   .1064308    86.63   0.000     9.011653    9.428854
```

```
       /lns2 |   9.249332   .0463773   199.44   0.000     9.158434    9.340229
         /r1 |  -1.098683   .3003404    -3.66   0.000    -1.687339   -.5100266
         /r2 |   .4318319   .1700285     2.54   0.011     .0985822    .7650816
-------------+------------------------------------------------------------------
     sigma_1 |   10099.62    1074.91                      8198.058    12442.26
     sigma_2 |   10397.61   482.2127                      9494.176    11387.02
       rho_1 |  -.8000254   .1081103                     -.9338075   -.4699659
       rho_2 |   .4068511    .141884                      .0982641    .6440604
------------------------------------------------------------------------------
LR test of indep. eqns. :            chi2(1) =     6.46   Prob > chi2 = 0.0111
------------------------------------------------------------------------------
```

- ttest GMperkg11 = GMperkg10 , unpaired

```
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
GMper~11 |      92    6086.084    515.2518    4942.122      5062.6    7109.569
GMper~10 |     292    7715.766    291.8836     4987.71    7141.296    8290.237
---------+--------------------------------------------------------------------
Combined |     384    7325.322    256.1222    5018.949     6821.74    7828.903
---------+--------------------------------------------------------------------
    diff |           -1629.682    595.0289               -2799.624   -459.7399
------------------------------------------------------------------------------
    diff = mean(GMperkg11) - mean(GMperkg10)                      t =  -2.7388
H0: diff = 0                                     Degrees of freedom =      382

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0032         Pr(|T| > |t|) = 0.0065          Pr(T > t) = 0.9968

.
. ttest GMperkg00 = GMperkg01 , unpaired

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
GMper~00 |      92    6303.837    210.1402    2015.594     5886.42    6721.255
GMper~01 |     292    4340.597    118.8937    2031.657    4106.596    4574.597
---------+--------------------------------------------------------------------
Combined |     384    4810.957    111.8666    2192.129    4591.007    5030.906
---------+--------------------------------------------------------------------
    diff |            1963.241    242.4457               1486.546    2439.936
------------------------------------------------------------------------------
    diff = mean(GMperkg00) - mean(GMperkg01)                      t =   8.0977
H0: diff = 0                                     Degrees of freedom =      382

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
```

```
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

- oneway GMperkg Markeoutlet , tab

```
     Market |
 outlet for |
  green and |          Summary of GMperkg
        dry |        Mean   Std. dev.       Freq.
------------+------------------------------------
         Lo |   4340.6492   10367.629         292
         Ur |   11219.233   12167.163           9
       Coop |   5448.6725   7559.7431          65
    Lo & Ur |   12913.393   281.57973           2
  Lo & coop |  7982.0371   995.9069             9
  Ur & coop |   7578.0391   5819.0789           3
Lo & Ur & coop|-3821.3889  32292.796            4
------------+------------------------------------
      Total |   4759.6877   10261.272         384
                      Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      1.0024e+09      6    167074452      1.60     0.1454
 Within groups      3.9325e+10    377    104310463
------------------------------------------------------------------------
    Total           4.0327e+10    383    105293711

Bartlett's equal-variances test: chi2(6) =  59.7734    Prob>chi2 = 0.000
```

- oneway TVCTArperkg Markeoutlet, tab

```
     Market |
 outlet for |
  green and |       Summary of TVCTArperkg
        dry |        Mean   Std. dev.       Freq.
------------+------------------------------------
  local mar |   2508.5973   8219.2031         292
  Urban mar |   6127.9894   4338.2065           9
  Cooperati |   4141.1562   6171.8405          65
  Local & U |   2149.1072   1607.4053           2
  Local coo |   913.00193   1392.8496           9
```

Urban& co	4708.2353	4366.0014	3
Local & U	17515.833	31838.887	4
Total	3004.0124	8314.9237	384

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	1.1354e+09	6	189241541	2.81	0.0108
Within groups	2.5344e+10	377	67226493.3		
Total	2.6480e+10	383	69137956.1		

Bartlett's equal-variances test: chi2(6) = 63.6945 Prob>chi2 = 0.000

- oneway RevTArperkg Markeoutlet, tab

Market outlet for green and dry	Summary of RevTArperkg Mean	Std. dev.	Freq.
local mar	6849.2465	6189.492	292
Urban mar	17347.222	10116.08	9
Cooperati	9589.8287	4415.1575	65
Local & U	15062.5	1325.8252	2
Local coo	8895.039	1462.7263	9
Urban& co	12286.274	3765.006	3
Local & U	13694.444	803.15723	4
Total	7763.7	6231.2358	384

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	1.6077e+09	6	267941931	7.62	0.0000
Within groups	1.3264e+10	377	35181928.2		
Total	1.4871e+10	383	38828299		

Bartlett's equal-variances test: chi2(6) = 39.1098 Prob>chi2 = 0.000

- sum Thinningweedingperkg Transperkg Pollinationperkg Harvestingperkg Processingperkg

Variable	Obs	Mean	Std. dev.	Min	Max
Thinningw~kg	384	2459.615	8107.862	0	100000
Transperkg	384	50.79601	238.767	0	3000
Pollinatio~g	384	236.9152	1127.296	0	10000
Harvesting~g	384	14.5692	171.7898	0	3200
Processing~g	384	242.1166	707.5528	0	6000

- oneway Thinningweedingperkg Markeoutlet, tab

Market outlet for green and dry	Summary of Thinningweedingperkg Mean	Std. dev.	Freq.
local mar	2149.9089	8131.7294	292
Urban mar	1770.3704	3338.4729	9
Cooperati	3393.555	5670.6862	65
Local & U	1428.5714	2020.3051	2
Local coo	549.7076	1316.3449	9
Urban& co	2666.6667	4618.8022	3
Local & U	16100	30870.399	4
Total	2459.6154	8107.8616	384

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	868304242	6	144717374	2.24	0.0385

```
 Within groups      2.4309e+10    377   64480444.8
-------------------------------------------------------------------------
    Total           2.5177e+10    383   65737420.2

Bartlett's equal-variances test: chi2(6) =  69.0159    Prob>chi2 = 0.000
```

- oneway Transperkg Markeoutlet, tab

```
     Market |
 outlet for |
  green and |        Summary of Transperkg
        dry |        Mean   Std. dev.       Freq.
------------+------------------------------------
  local mar |   18.493151   185.24463         292
  Urban mar |   430.55556   557.36857           9
  Cooperati |    112.6948   309.69697          65
  Local & U |   233.92857   128.79445           2
  Local coo |   11.111111   33.333333           9
  Urban& co |   252.54902   141.59415           3
  Local & U |         395   458.50491           4
------------+------------------------------------
      Total |   50.796007   238.76701         384

                      Analysis of variance
    Source              SS         df      MS            F     Prob > F
-------------------------------------------------------------------------
Between groups      2528962.88       6   421493.813      8.23     0.0000
 Within groups        19305746     377   51208.8753
-------------------------------------------------------------------------
    Total           21834708.9     383   57009.6837

Bartlett's equal-variances test: chi2(6) =  81.7783    Prob>chi2 = 0.000
```

- oneway Pollinationperkg Markeoutlet, tab

```
     Market |
 outlet for |
  green and |     Summary of Pollinationperkg
        dry |        Mean   Std. dev.       Freq.
------------+------------------------------------
  local mar |   181.17548   931.34845         292
  Urban mar |   1656.4815   3305.4663           9
  Cooperati |   316.36696   1398.4707          65
  Local & U |           0           0           2
  Local coo |           0           0           9
```

```
  Urban& co |         400   692.82032           3
  Local & U |   350.00001   432.57294           4
------------+------------------------------------
      Total |   236.91517   1127.2961         384
```

```
                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      20202412.7      6   3367068.79      2.72     0.0134
 Within groups       466512605    377   1237433.96
------------------------------------------------------------------------
    Total            486715018    383   1270796.39
```

```
Bartlett's equal-variances test: chi2(4) =  67.6284    Prob>chi2 = 0.000
```

```
note: Bartlett's test performed on cells with positive variance:
      2 multiple-observation cells not used
```

- oneway Harvestingperkg Markeoutlet, tab

```
     Market |
 outlet for |
  green and |     Summary of Harvestingperkg
        dry |        Mean   Std. dev.       Freq.
------------+------------------------------------
  local mar |   13.002722    189.2277         292
  Urban mar |   33.333333         100           9
  Cooperati |   10.256411   82.689826          65
  Local & U |           0           0           2
  Local coo |           0           0           9
  Urban& co |          40   69.282032           3
  Local & U |   177.77778   282.84271           4
------------+------------------------------------
      Total |     14.5692   171.78982         384
```

```
                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      115917.582      6   19319.5969      0.65     0.6893
 Within groups      11187079.2    377   29673.9503
------------------------------------------------------------------------
    Total           11302996.8    383   29511.7411
```

```
Bartlett's equal-variances test: chi2(4) =  53.2084    Prob>chi2 = 0.000
```

- oneway Processingperkg Markeoutlet, tab

Market outlet for green and dry	Summary of Processingperkg Mean	Std. dev.	Freq.
local mar	146.01705	501.6624	292
Urban mar	2237.2487	2264.5128	9
Cooperati	308.283	703.81886	65
Local & U	486.60715	284.1054	2
Local coo	352.18323	189.49125	9
Urban& co	1349.0196	927.1255	3
Local & U	493.05555	493.42873	4
Total	242.11656	707.55284	384

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	42962360.5	6	7160393.42	18.14	0.0000
Within groups	148779322	377	394640.112		
Total	191741683	383	500631.026		

Bartlett's equal-variances test: chi2(6) = 104.3341 Prob>chi2 = 0.000

Appendix E: Publication

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Determinants of Choice of Market Outlets among Smallholder Vanilla Farmers in Antalaha District, Madagascar

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Abstract

This paper examines the factors that influence the choice of vanilla market outlets among smallholder farmers in the Antalaha district, Madagascar. A cross-sectional survey of 384 vanilla farmers was conducted in Antalaha district, Madagascar. Data was collected using a semi-structured questionnaire and personal interviews. For data analysis, descriptive statistics and a multivariate probit model were used. The data was analyzed using SPSS and STATA software. Multivariate probit model results show that gender, education level, off-farm income, land ownership, group membership, vanilla yield, dry vanilla, and green vanilla significantly influence the choice of market outlets among smallholder vanilla farmers. This study recommends the need to enhance educational initiatives, improve market access, provide agricultural training, and develop infrastructure to help smallholder vanilla farmers overcome market limitations and optimize their choice of profitable market outlets.

Keywords: Vanilla, Choice of market outlets, Smallholder farmers, Green and dry vanilla

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