A profitability and risk assessment of market strategies for potato producers in South Africa

By

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DECLARATION

I, Jodie Vosloo, declare that the thesis/dissertation, which I hereby submit for the degree MSc (Agric) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE: ...…………………………

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Greetings

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ABSTRACT

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Department : Agricultural Economics, Extension and Rural Development

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The South African potato producers have four primary forms of market channels to market and sell their fresh produce: export markets, direct markets, national fresh produce markets (NFPM), and online markets. Potatoes contribute the largest share of the vegetable gross production value, approximately 37% (DALRRD, 2020), with the majority sold through the NFPM. The NFPM has seen a decrease in market participation on the entire market channel in recent years and has been underperforming for five consecutive years (Lekgau, 2016, Meyer, 2020). Producers who are still choosing NFPM as a marketing channel see lower demand due to less buyers participating in the market channel. In the long run, lower demand will lead to lower prices received by producers, which affects their profitability. According to Meyer (2020), a solution to counter the effects seen on the NFPM is for producers to diversify their marketing channels. South Africa has an online fresh produce trading platform. Online markets provide an alternative to NFPM and are therefore a diversification option.

One benefit of market diversification is increased profitability (Dohlman, 2020). There is a need to provide producers with quantifiable research of the profitability effects of online markets and NFPM market diversification. The second benefit of market diversification is decreased risk. The way producers perceive risk depends on their

risk preference. The preference affects their choice of market channel as each channel and combination of channels have different risks associated with it (Pennings and Wansink, 2004). To provide producers with a complete and comparable assessment of online and NFPM market channels, not only the market channels need to be evaluated, but the marketing strategies of different combinations of market channels also need to be analysed (Kim et al., 2014).

The purpose of this study is to provide fresh potato producers with a framework to compare marketing strategies comprising of different market channel combinations for online market and NFPM markets. The Study, therefore, determines which marketing strategies are the most profitable based on different combinations of market channels and evaluate if different risk preferences affect producers marketing strategy choice. Simulation models are commonly used to access production, market, and price risk in traditional agriculture (Curtis et al., 2014, Hardaker et al., 2004, Jordaan et al., 2007, Richardson et al., 2007b). Therefore, this study uses a simulation model analysis that combines market channel price, yield, and market channel risk to construct a probability distribution function that shows the profitability for eleven marketing strategies. The risk preference analysis is completed using stochastic efficiency with respect to a function (SERF) approach created by Hardaker et al. (2004) to analyse risk preferences of different marketing strategies. Ranking simulation and risk analysis enable a framework to compare marketing strategies comprising of different market channel combinations for online market and NFPM market.

This study's main objective to provide a framework for producers to compare marketing strategies is also accomplished by ranking the results from the simulation and risk analysis methods. The first proposition proposed that fresh potato producers' profitability is higher for the online market channel due to lower marketing cost. The results from the simulation model have shown that the highest possible net return for all eleven marketing strategies is the M1 market strategy, sending all of the producers’ production to the online markets. The M1 marketing strategy can provide a potato producer with net returns of up to R105 381 per ha. The second proposition states that a fresh potato producer, who is risk-averse, will prefer to send most of their produce to the NFPM. The third proposition proposes that risk-neutral potato producers will prefer to send most of their potatoes to online markets. This study's risk preference analysis result disproves the second and third proposed propositions. The results found that a risk-averse producer prefers to send 40% of their potatoes to NFPM and not the majority, and a risk-neutral producer will prefer to send all their potatoes to NFPM.

The study will therefore make academic, managerial and policy contributions. The new information on online markets will add to the knowledge base of the current fresh produce industry within South Africa. The framework will assist producers in their farm management practices by providing a quantitative assessment of their marketing strategies based on personal risk preference and profitability. This study provides policymakers with a quantified risk assessment of alternative marketing strategies.

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LIST OF ABBREVIATIONS

APAC	Agricultural produce agent's council
ARAC	Absolute risk aversion coefficients
BW	Best-worst
CDF	Cumulative probability distributions
CE	Certainty equivalence
CSA	Community supported agriculture
CV	Coefficient of variation
EU	Expected utility
GPV	Gross production value
KOV	Key output variables
LC	Latent-class
LR	Likelihood ratio
LRAC	Lower risk aversion coefficient
MNL	Multinomial logit
NFPM	National fresh produce market
OLS	Ordinary least squares
PE	Partial equilibrium
RAC	Risk aversion coefficients
SADC	Southern African development community
SDRF	Stochastic dominance with respect to a function
SERF	Stochastic efficiency with respect to a function
TFPM	Tshwane fresh produce market
URAC	Upper-risk aversion coefficient

CHAPTER 1 : INTRODUCTION

1.1 BACKGROUND

With 2.67 million tonnes of potatoes produced in 2019 (DALRRD, 2019), South Africa contributes only 1% of global potato production (FAOSTAT, 2021). China (91 million tonnes, 25% of world production), India (50.2 million tonnes, 14%), the Russian Federation (22.1 million tonnes, 6%), Ukraine (20.2 million tonnes, 5%) and the United States (19 million tonnes, 5%) were the top potato producers and consumers in 2019 (FAOSTAT, 2021). Even though South Africa, compared globally, is a small potato producing country, potatoes are one of the most important vegetable crops in South Africa. It is not only one of South Africa's staple foods, but it also provides livelihoods for producers and labourers with significant upstream and downstream effects throughout the potato value chain (van der Westhuizen, 2013). Potatoes form part of the fresh produce industry, which is a unique sector within agriculture, with higher time turnover than any other sector (Du Preez, 2011). Its uniqueness is characterised by high perishability, susceptibility to shocks, and seasonality, giving grounds for price volatility. The uniqueness combined with price volatility has led to an increase in its marketing complexity, forcing producers to rely on spot market prices rather than list prices like other sectors (Louw et al., 2004). Spot markets are defined as a public financial market where commodities are traded for immediate delivery whereas listed markets are for delivery at a future date (Geyser, 2013).

The fresh produce industry's spot market is known as the national fresh produce markets (NFPM), with potatoes being the highest trade vegetable with 1.18 million tons in 2019, as shown in Figure 1.1. Other market channels available to producers in the fresh produce industry is direct markets, online markets and export markets. Although the NFPM is the national price-setting platform for fresh produce (NAMC, 2007), market participation in terms of quantity demanded has decreased in recent years (Lekgau, 2016, Meyer, 2020). A decrease in market participation leads to a decrease in supply and demand in the NFPM. Producers who are still choosing NFPM as a marketing channel will see lower demand due to less buyers participating in the market channel. In the long run, lower demand will lead to lower prices received by producers, which affects their profitability. Profitability is defined as the degree of financial gain of a business and its profit margin, operating profit margin and net return (Lee et al., 2020, Mehdi et al., 2019).

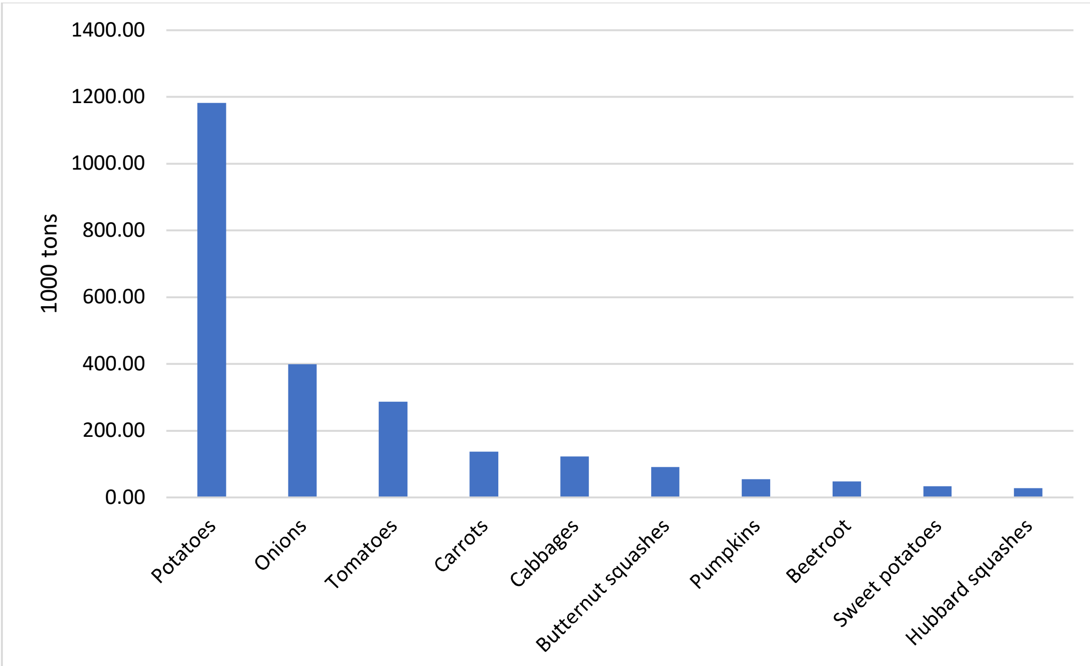

Figure 1.1: Quantity of top 10 produce traded on all NFPM in 2019

Source: DALRRD (2020)

According to Meyer (2020), a solution to counter the effects on producers of decreased participation in NFPM is diversifying market channels. Diversification of producers' market channels is accomplished by allocating produce to different market channels. Diversification will enable different market channels to meet the demand, and therefore a fair price will be realised, improving producers profitability. Diversification of market channels not only increases profitability but also decreases risk exposure (Hardaker, 2000). Risk is defined as exposure to uncertainty. There are numerous types of risk in agribusiness, but the risk associated with market channels is price or market risk (Dohlman, 2020). Price risk is the uncertainty about prices producers will receive in any given market channel. Market risk is the uncertainty associated with the price received in a given market and the cost of market channel participation. Risk is measured by the amount of volatility between actual and expected values and is most often measured through the standard deviation or coefficient of variation (Richardson et al., 2007a).

How much a producer participates in each market channel depends on their marketing strategy. A marketing strategy refers to a producer plan for reaching prospective consumers and turning them into customers. The marketing mix is a concept used by producers when their marketing strategies are developed. McCarthy (1960) suggests the four P's of marketing: price, promotion, product and place. Booms (1981) extended the four P's to seven P's, including people, processes, and physical evidence. A producer's marketing strategy choice is therefore unique.

1.2 PROBLEM STATEMENT

As a result of decreased market participation in NFPMs in recent years (Lekgau, 2016, Meyer, 2020), producers effectively experience less demand from the NFPM, putting producer price under pressure. By diversifying market channels, producers can counter the effects (Meyer, 2020) of decreased market channel participation by sending potatoes to another market channel, splitting supply and not oversupplying one market channel. The benefits of market channel diversification are increased profitability and decreased risk exposure. To enable South African potato producers to diversify their market channels, the impact of market diversification needs to be quantified. The impact of diversification on producers can be quantified with a profitability and risk assessment of the market channels under investigation (Kim et al., 2014). An alternative market channel to NFPM needs to be identified as a diversification option.

There are three alternative market channels in South Africa potato producers can send their produce to including export markets, direct markets, and online markets. The export market is mainly targeted by high-value produce. Strict grading and phytosanitary rules need to be adhere to in the export market. This limits the marketing channel for many producers as the process is costly and therefore not a comparable alternative market channel to NFPM. Direct markets involve purchasing fresh produce directly from the producer for own consumption or selling and distributing for a profit which is predominantly contract based selling. Direct markets encompass a wide variety of sub-channels such as hospitality, public sector, processing, retail, farmer markets, informal markets or hawkers. Each sub-sector has its own structure and complexity with limited market access and therefore not a comparable alternative market channel to NFPM. Online markets are defined as e-commerce sites where producers can sell their products or services (Hendricks, 2020). These markets function similarly to the physical fresh produce markets, except that the entire transaction is facilitated online. Produce sold through online markets bypass the process of being transported to a market floor by delivering directly to the buyer once the transaction is conducted. Online markets in South Africa function similarly to the NFPM and are, therefore, a diversification option.

After extensive research, literature on profitability and marketing strategies of fresh produce online markets in South Africa, could not be found. International literature on fresh produce online markets profitability were on retail level (He et al., 2019, Boccaletti and Nardella, 2000) which is not comparable to South African fresh produce online markets. There is a need to provide producers with quantifiable research of the profitability effects of online markets involvement as a market diversification channel. A review of international literature found two approaches that can quantify profitability. One approach evaluates the revenue of different market channels (Feuz et al., 1993, Lee et al., 2020). A different approach uses net return or profit as the analysis method (Mehdi et al., 2019, Hardesty and Leff, 2010). A revenue only approach incorporates only the price and quantity sold and therefore does not describe the impact that different market channels provide. Net return or profit analysis includes the deduction of cost that enables the analysis of the effect of a market channel back on the farm, which will quantify the direct impact to producers. The second benefit of market diversification is decreased risk. Even with the decreased marketing cost and profitability benefits, online markets present to producers' online markets are still considered riskier by potato producers, according to communication by Van Zyl (2020), manager of industry information at Potato SA. The way producers perceive risk depends on their risk preference. The preference affects their choice of market channel as each channel and combination of channels have different risks associated with it (Pennings and Wansink, 2004). For producers, the involvement in online markets and NFPM markets presents a strategic trade-off between profit and risk preference, the extent which has yet to be assessed.

The marketing strategies of different combinations of market channels also need to be analysed (Kim et al., 2014), to provide producers with a complete and comparable assessment of online and NFPM market channels. An extensive literature study revealed that there has yet to be any profitability and risk assessments of the marketing strategies for potato producers in South Africa. An analysis that can provide producers with a framework to compare market strategies based on profitability and risk is absent within the potato industry of South Africa.

1.3 CONCEPTUAL FRAMEWORK

Market channel diversification benefits are quantifiable through a profitability and risk assessment. The first assessment methods profitability can be calculated through net return (Mehdi et al., 2019, Hardesty and Leff, 2010). Market channels have different risks associated with them, and the way producers perceive risk depends on their risk preference. Therefore, the second assessment method can be quantified through producer risk preference towards a market channel.

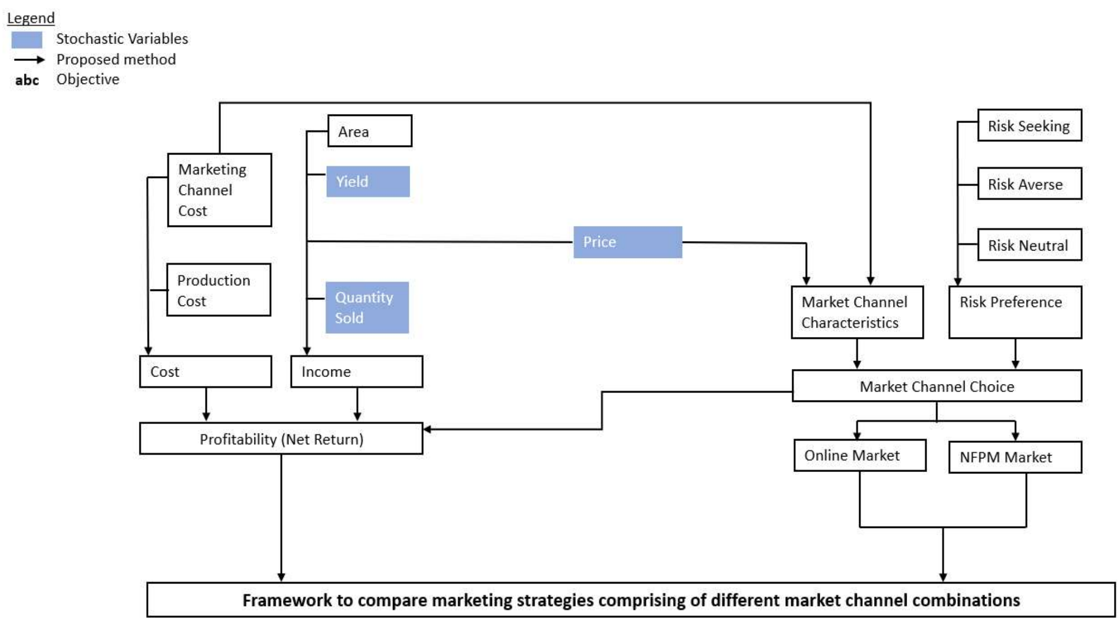

Figure 1.2: Conceptual framework

Source: Author's own compilation

Profitability is calculated through net return (Mehdi et al., 2019, Hardesty and Leff, 2010). Net return is calculated by subtracting cost from income, as detailed in Figure 1.2. There are two cost components, production cost and marketing channel cost. The variables that determine income are production and sales. Production is calculated through yield and area planted. Sales are calculated through the price received and the quantity sold. Yield, price, and quantity sold are considered risky variables as they cannot be determined before planting. Risky variables are defined as being stochastic (Richardson et al., 2006a).

Market channel choice is affected by the characteristics of the market, which is price and marketing cost (Figure 1.2). Online markets have 4% higher prices and 6% lower costs than NFPM (Freshlinq, 2019). The other variable that affects market channel choice is how a producer perceives the risk in the market channel (Pennings and Wansink, 2004). Producers can risk preference can be risk-seeking, risk-neutral or risk-averse. In this study, the two market channel producers can choose their involvement in is online market and the NFPM market. Producers can participate in combinations of each market channel. Since each market channel characteristics are also variables of profitability, market channel choice directly affects profitability.

Each channel and combination of channels have different risks due to the stochastic variables influencing the market channel. For producers, the involvement in online markets and NFPM markets presents a strategic trade-off between profit and risk preference. Therefore, the combination of different market channel involvement provides producers with different marketing strategies (Kim et al., 2014). By quantifying this trade-off, a comparative framework of different marketing strategies will be provided to the producer.

1.4 RESEARCH OBJECTIVES

The purpose of this study is to provide fresh potato producers with a framework to compare marketing strategies comprising of different market channel combinations for online market and NFPM markets.

The following specific objectives will guide the study:

1. To determine which marketing strategies are the most profitable based on different combinations of market channels
2. To evaluate if different risk preferences affect producers marketing strategy choice

1.5 PROPOSITIONS

The study aims to test the following propositions:

1: Fresh potato producers' profitability is higher for the online market channel due to lower marketing cost.

It is proposed that the online marketing channels are more profitable for fresh potato producers due to the lower marketing cost received in the online market channel compared to the NFPM channel. Research has shown that lower cost leads to higher profitability in agriculture (Kim et al., 2014, Hardesty and Leff, 2010).

2: A fresh potato producer, who is risk-averse, will prefer to send most of their produce to the NFPM

3 Risk-neutral potato producers will prefer to send most of their produce to online markets

It is proposed that a risk-averse producer would prefer a marketing strategy that allocates most of the produce to the NFPM as the risk of selling produce on the online market is perceived as being higher, and the opposite is true for risk-neutral producers. Research has shown that market channels with a smaller coefficient of variation on prices, which is indicative of risk, is preferred by risk-averse producers (Kim et al., 2014).

These propositions are extensively discussed and thoroughly tested in subsequent chapters of this dissertation. The study will therefore make academic, managerial and policy contributions. The new information on online markets will add to the knowledge base of the current fresh produce industry within South Africa. The ideal marketing strategy will provide insights in a world where online markets are increasingly important. The framework will assist producers in their farm management practices by providing a quantitative assessment of their marketing strategies based on personal risk preference and profitability. This study will provide policymakers with a quantified risk assessment of marketing strategies.

1.6 STUDY OUTLINE

This study consists of five Chapters. Chapter two presents an overview of the South African potato industry and its research on production and price trends and market channels analysis within an international and national context. Chapter three discusses the study's design and follows with a comprehensive description of the methodology used in this study. The fourth chapter gives an overview of the historical data using descriptive statistics. This is followed by simulation results, risk preference analysis and provides the rankings framework. Chapter five is the final chapter with concluding remarks and referrals.

CHAPTER 2 : LITERATURE REVIEW

2.1 INTRODUCTION

According to the Abstract of Agricultural Statistics (DALRRD, 2020), the gross production value (GPV) of vegetables during 2019 in South Africa is R21.58 billion. Potatoes contribute the largest share of the vegetable gross production value, approximately 37%, as seen in Figure 2.1, followed by green mealies (27%), tomatoes (13%) and onions (11%).

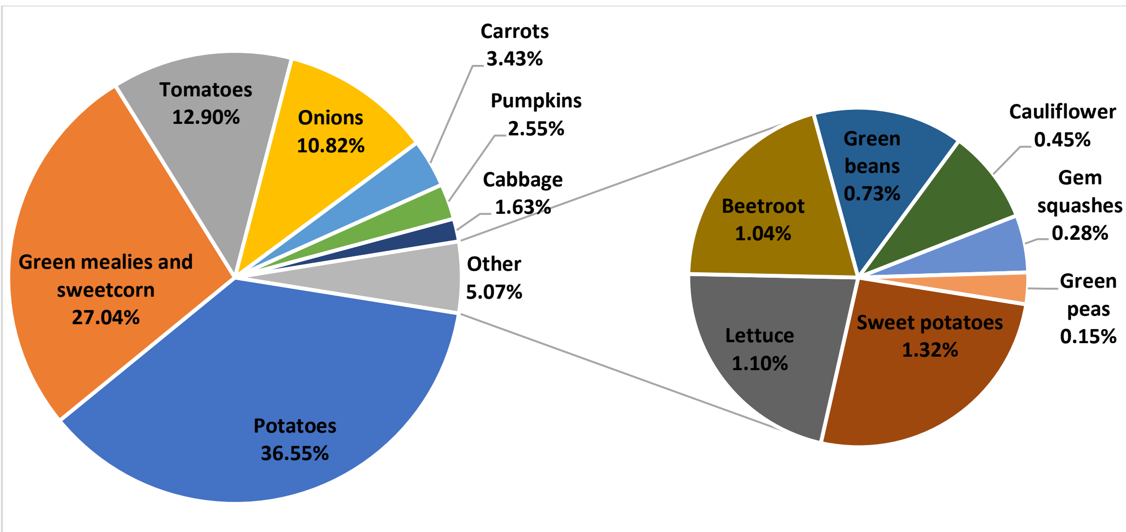

Figure 2.1: South African gross production value of vegetables in 2019

Source: DALRRD (2020)

The South African potato value chain is shown in Figure 2.2. Of the 2.48 million tons produced, 8% is seed potato production, and 92% is fresh potato production. Packaging depends on the final market channel and can vary from 1kg bag to 500kg bins. Predominantly only processors and manufacturers accept bin delivery, and the rest of the market channels work with 10kg bags. Producers most often have packaging facilities on-farm where potatoes are sized and packaged for their intended market channels. Close to half of potato production is sold through national fresh produce markets (NFPM) (47%) market channel, with direct market channel estimated to account for 38% and Export market channel accounting for 6% of production.

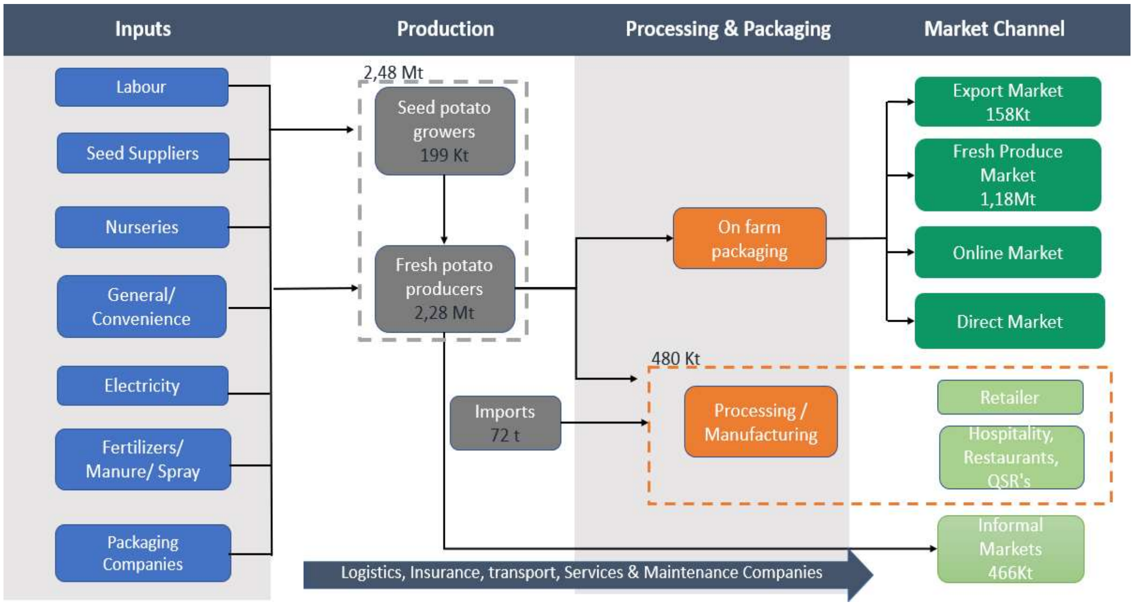

Figure 2.2: Fresh potato value chain

Source: Author's own compilation from BFAP (2020), Hoffman (2017) and Fernandez-Stark et al. (2011)

This chapter's first part is an overview of the South African potato industry. This is followed by a detailed description of the fresh potato market channels under investigation in this study. The fourth section looks at international and national studies on fresh produce market channel analysis and theory. Section four is followed by an evaluation of market strategy frameworks in literature.

2.2 SOUTH AFRICAN POTATO INDUSTRY

Potatoes are produced across South Africa in different climatic regions, ensuring a constant potato supply. The major potato producing areas in South Africa, as seen in Table 2.1, are the Limpopo and Free State regions which contribute 56% of total production from the 16 potato production regions. Potato production has seen a steady year on year increase over the last ten years except for the 2012 and 2016 seasons (Figure 2.3). In 2012 a decrease in yields were seen in all production regions across South Africa (van der Westhuizen, 2013), which can be attributed to the increase in electricity cost linked to irrigation practices (Troskie, 2013). The South African potatoes are predominantly produced under irrigation (81%) (Potato SA, 2017). A study by Troskie (2013) quantified the impact of higher electricity tariffs on production using a supply response model.

Table 2.1: Potation production regions and contribution to 2019 crop

Source: Potato SA (2020)

Production Region	Percentage of Total	Production Region	Percentage of Total
Limpopo	21.91%	North-Eastern Cape	3.46%
Eastern Free State	15.70%	South-western Free State	3.39%
Western Free State	15.34%	Mpumalanga	3.20%
Sandveld	10.30%	South Western Cape	1.48%
Northwest	6.81%	Southern Cape	1.48%
Northern Cape	6.66%	Eastern Cape	0.73%
KwaZulu-Natal	5.18%	Ceres	0.43%
Marble Hall	3.80%	Gauteng	0.14%

The results indicated that production regions would see a decrease in hectares planted in the period between 2013 and 2020 due to the increased electricity tariffs. Troskie (2013) results are evident in Figure 2.3, with a decrease in production in 2012/2013 and 2013/2014. The trend predicted by Troskie (2013) did not continue for the rest. This could be attributed to the cost increase being carried over to the price of potatoes from 2014 (Figure 2.7), leading to increased area planted and production. The decrease in the 2016 production (Figure 2.3) season results from the severe drought seen in KwaZulu-Natal and Free State province. The Free State regions contribute 30% to the total production, and a decrease in dryland production in these regions can cause the 1% decrease in the 2016 season national production (Table 2.1).

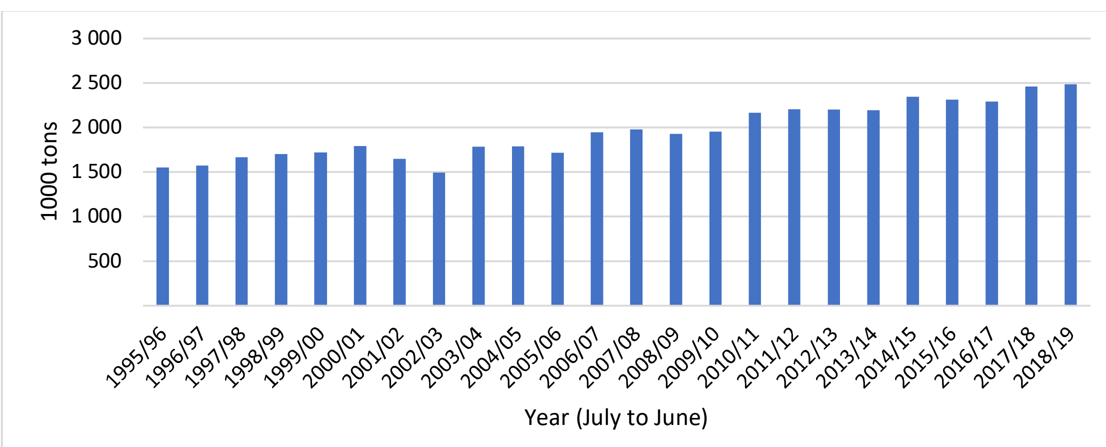

Figure 2.3: Annual South African potato production from 1995 to 2018

Source: DALRRD (2020)

Figure 2.4 represents the South African fresh potato trade from 2001-2019. Export increased significantly from 2009 to 2011, which is in line with the production increase during the same period. The import into the country is extremely low, with only a few hundred tons imported annually which means South Africa is a net exporter of potatoes. With an export quantity of between 140 000 and 150 000 tons annually, South Africa only export on average 6% of total production. South Africa is considered self-sufficient in potato production as low amounts of potatoes are imported, and a small percentage is exported; therefore, local production meets local demand.

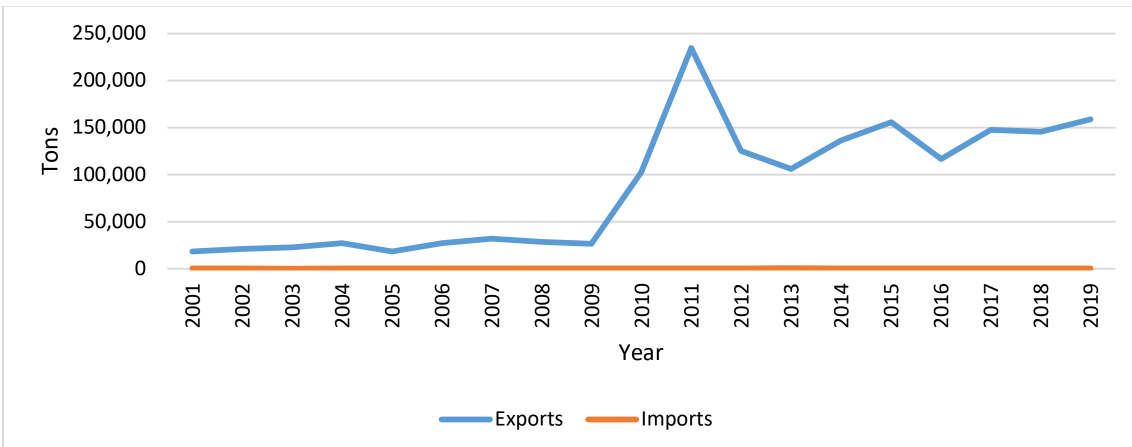

Figure 2.4: South African annual fresh potato trade from 2001 to 2019

Source: ITC (2020)

Mhlabane (2012) confirmed self-sufficient potato production by developing a partial equilibrium (PE) model for the South African potato industry. The PE model is used as a scenario tool to analyse the potential impact of relative environmental shifts on the South African potato industry, such as changes in rainfall or yields. The study confirmed that the model could be utilised to assist in the decision making and develop preventive measures and strategies for the possible environmental impacts. The study results also showed that the South African market equilibrium price closed the PE model; therefore, implying the potato industry is not trade-driven and self-sufficient. The result from Mhlabane (2012) study answered a vital question stated in a study by Chogo (2010). Mhlabane (2012) results of the potato industry not being trade-driven explain the lack of integration highlighted by Chogo (2010). The study by Chogo (2010) analysed the impact that deregulation had on the competitiveness and the integration level in the South African potato industry within the Southern African development community (SADC). The two-fold analysis approach looked at the real trade advantage analysis to indicate competitiveness and a price transmission analysis for other impact analysis. The study results found that South Africa's fresh potato exports are the most competitive to the SADC countries. The results are confirmed by Figure 2.5, showing that most of South Africas fresh potato exports are to SADC countries. During the 2019 season, 52.5% of South Africa's potato exports headed to Mozambique. Chogo's (2010) study also found that the South African potato industry is not well integrated with other regional potato markets.

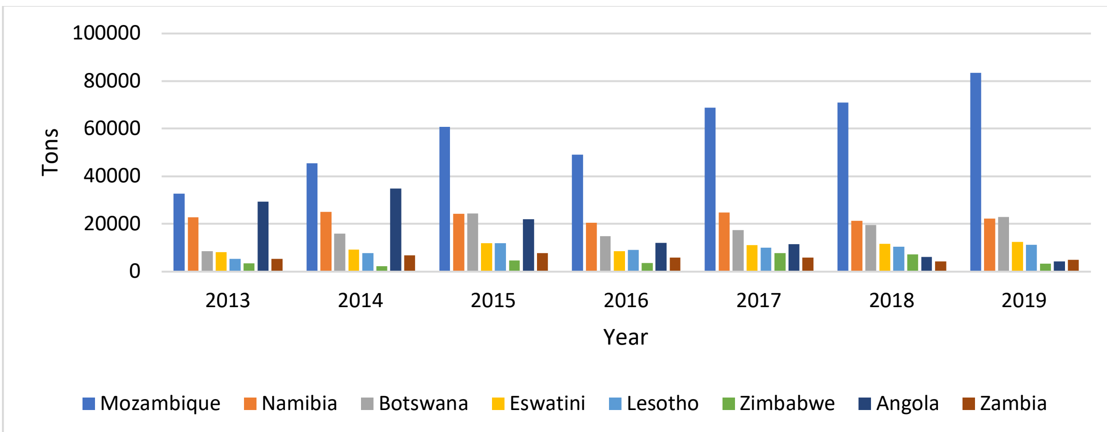

Figure 2.5: Export countries of South African fresh potatoes from 2013 to 2019

Source: ITC (2020)

2.3 FRESH POTATO MARKET CHANNELS

The South African fresh potato producers have four main market channels (Figure 2.2). The market channels are the export market, direct markets, NFPM and online markets. The export market is mainly targeted by high-value produce. Strict grading and phytosanitary rules need to be adhered to in the export market. This limits the marketing channel for many producers as the process is costly and timely. Direct markets involve purchasing fresh produce directly from the producer for own consumption or selling and distributing for a profit. Direct markets encompass a wide variety of sub-channels such as hospitality, public sector, processing, retail, farmer markets, informal markets or hawkers. NFPM are the main marketing channel for producers of fresh produce. The NFPM is the price-setting platform for the fresh produce industry, one of the few agricultural industries in South Africa that still relies on the spot market for prices rather than list prices (Louw et al., 2004, Rathogwa et al., 1998). Currently, there are only two online markets in South Africa Freshlinq and Hello Choice. These markets function similarly to the physical fresh produce markets, except that the entire transaction is facilitated online. Produce sold through online markets bypass the process of being transported to a market floor by delivering directly to the buyer once the transaction is conducted.

According to BFAP Baseline outlook (2020), for the period of 2020 to 2029, the short-run potato prices are estimated to decline by 16% due to a decrease in demand. The decrease in demand experienced results from the COVID-19 national lockdown, causing logistical challenges. In response to the lower estimated prices, the 2021 area planted is projected to decline by 1.9%. However, the long-run outlook is favourable, with the potato production projected to increase by 0.8% annually and real prices expect to keep up with inflation.

2.3.1 NATIONAL FRESH PRODUCE MARKETS

The biggest market for South African potatoes produced is the NFPM. As seen in Figure 2.6, on average, half of potato production is sold through the NFPM. In 2019 47.5% of potato production was sold on the NFPM.

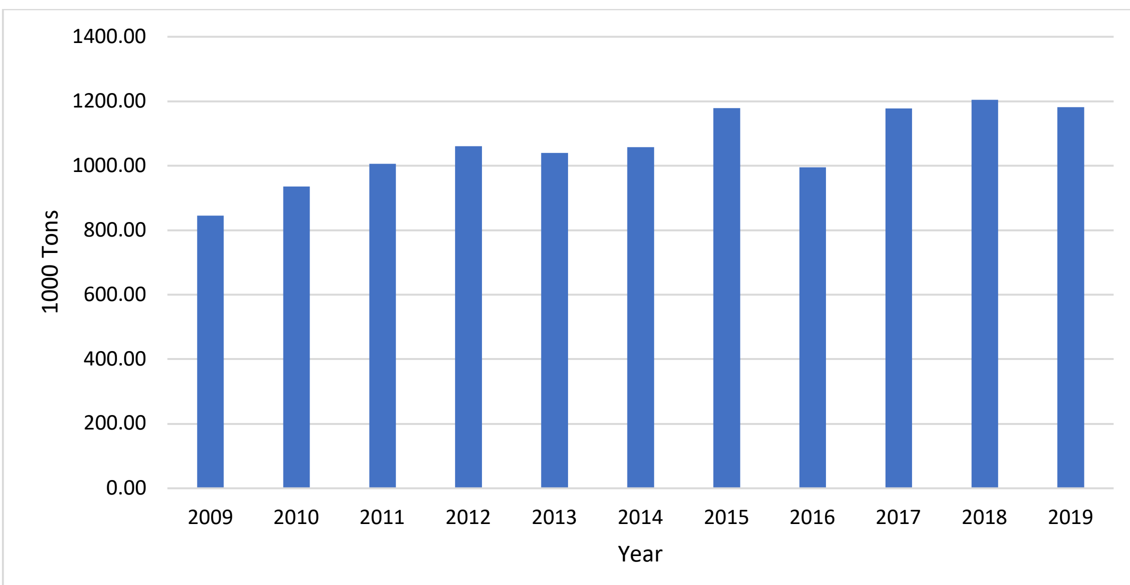

Figure 2.6: Annual quantity of fresh potatoes sold on major NFPM from 2009 to 2019

Source: DALRRD (2020)

Initially, NFPM started as a meeting place for producers and consumers in South Africa to trade under government officials' control (Euromonitor-International, 2010). Currently, the NFPM is South Africa's only formal marketplace where supply and demand meet to establish a value and is the price-determining mechanism of the industry (Louw et al., 2004). Figure 2.7 indicates the annual price per kilogram for potatoes sold on the NFPM. The most significant jump in price was seen in 2016, which resulted from lower production that decreased supply, leading to higher prices. Besides supply and demand, other factors determine prices, producer cost being one of them. A study by Troskie (2013) quantified the true impact of higher electricity tariffs on market prices within the fresh potato industry. The study used a supply response econometric model in its analysis. The results demonstrated that the impact of higher electricity tariffs on market prices is small and will most likely be absorbed by the farmers. Prices did increase in 2012 and therefore disproved Troskie (2013) results.

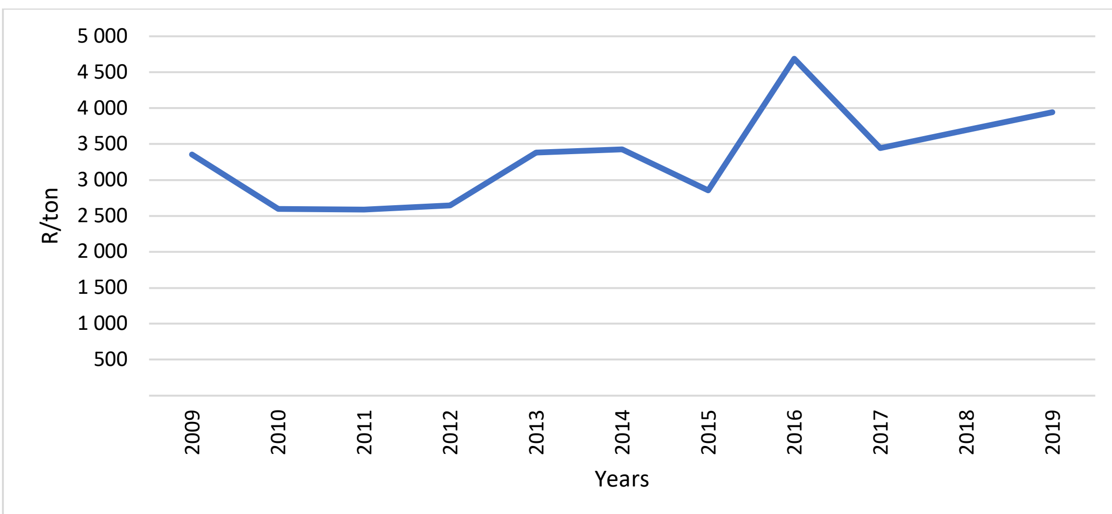

Figure 2.7: National annual potato prices on all major NFPM from 2009 to 2019

Source: DALRRD (2020)

There are 22 fresh produce markets, with the four largest being Johannesburg, Tshwane, Cape Town and Durban (DALRRD, 2019). These four markets represent 80% of the quantity sold of all fresh produce markets. The breakdown of the market shares can be seen in Figure 2.8. Johannesburg is by far the biggest market in terms of value and quantity sold, contributing more than double the share than the second largest market being the Tshwane market.

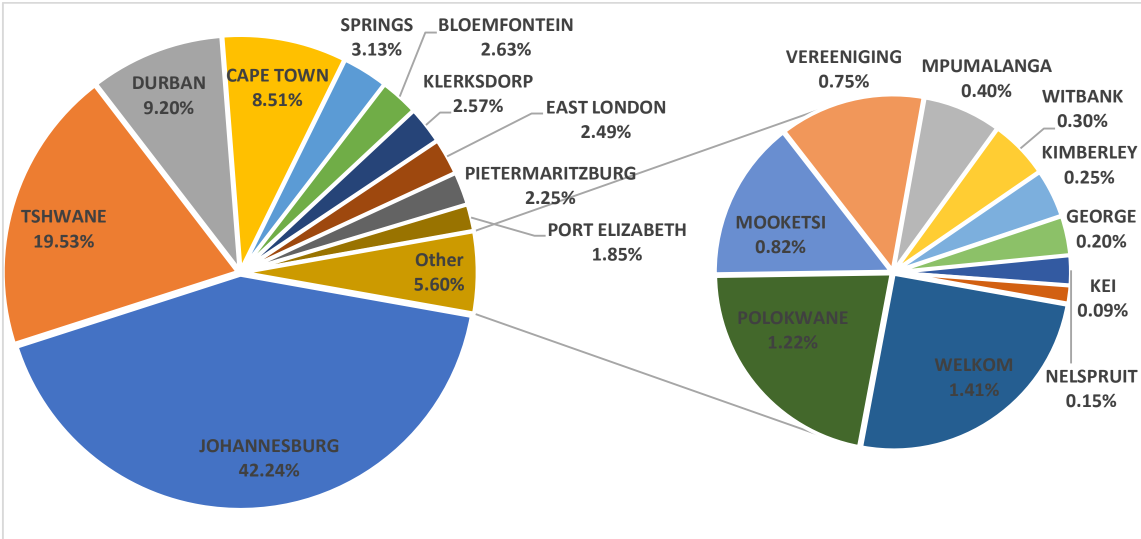

Figure 2.8: Share per market of quantity (tons) sold on all fresh produce markets

Source: DALRRD (2019)

To determine the relationship between the different NFPM, Du Preez (2011) analysed if NFPM were integrated in the fresh potato industry. The study found that in the long run, co-integration was present between NFPM and that there was a one-directional flow with the Johannesburg NFPM being the primary destination market. Identifying that markets are integrated indicates that changes that affect prices in one market will affect other markets and suggest that markets are uniform in their price formation.

NFPM are either privately owned or owned by the government. Six of the twenty-two NFPM markets are privately owned, namely Cape Town, Nelspruit, George, Polokwane, Vereeniging and Mooketsi. Governmentally owned markets are owned and managed by the various municipalities of its regions, and when it is privately owned, it is managed by companies. Nobandala (2014) revealed that the regulatory environment in which NFPM operates is the most significant contributing factor to slow responses to competition. The Johannesburg market was corporatised in 2000, separating ownership and management structures (Bekker, 2019). A study by Louw et al. (2016) evaluated whether corporatisation of Municipal entities will enable NFPM to improve their institutional sustainability in light of increasing competition created by direct contracting of retailers. A case study (Louw et al., 2016) on the institutions within the Tshwane fresh produce market (TFPM) showed that its current institutions are not optimally structured to be competitive. Louw et al. (2016) showed that corporatisation is needed to enhance its competitiveness.

The management and ownership of NFPM do not affect the commission-based structure which all NFPM uses. The NFPM is the only formal market globally that works on a commission basis (Jansen, 2017). The commission-based structure is governed by legislation, Agricultural produce agents Act (12/1992) (hereafter referred to as the Act). The commission structure uses agents that act on behalf of a principal (producer) by selling the principal's produce to buyers such as hawkers, wholesalers, and retailers. The structure enables produce being sold through a NFPM to remain the producer's property until an agent sells it. Each market agent is part of a market agency that needs to be licenced to trade on any NFPM. The NFPM provides the infrastructure to the agencies to efficiently trade producers produce. Under section two of the Act, the agricultural produce agents council (APAC) was established as a juristic body that trains, licenses and disciplines market agents and agencies. The Act requires market agencies to open a trust account to handle producers' money, ensuring it is controlled and monitored. A Trust account reconciliation needs to be submitted to APAC monthly by all registered market agencies and submit an annual audit report to ensure transparency and safeguarding of producer's monies. A secondary safeguard system that the Act provides to producers is the market agents fidelity fund. The fund that only market agents contribute to is a statutory protection fund. It aims to protect producers from direct losses due to their market agent and to which a producer can claim agents to compensate their losses, under certain circumstances set out by the Act.

Market agents are not employees of the market itself but instead represent the producer's interest and facilitate all sales on behalf of the producer. Due to the agent's commission structure, it is in the agent's best interest to negotiate the best possible price on behalf of the producer. An agent's commission is around 7.5% on most produce except for potatoes and onions, where producers and agents negotiate lower commissions due to high volumes of the produce being sold through the fresh produce market (Jansen, 2017). The markets on which the agents' trade adds a further 5% commission which is used for the upkeep of the infrastructure and facilities. Under the Act that APAC enforces, agencies must pay the producers within five days after a trade has been concluded. Therefore, the Act protects the producer by prescribing how a producer's money should be controlled.

After producers have appointed an agent, produce can be sent to the market in accordance with packaging legislation and inspection protocol. Produce that does not comply with packing and inspection protocol will not be accepted, as confirmed by Simelane (2015). Simelane (2015) looked at the requirements and necessary conditions that enable black commercial producers to access NFPM. Simelane (2015)used a combination of situational analysis, descriptive statistics, ordinal logistic regression model and supply chain analysis in his study. Simelane (2015) analysed fresh produce market access for commercial black farmers and found that the quality, consistent quantity, and appropriate transport of fresh produce is essential to ensure access to NFPM.

2.3.2 ONLINE MARKETS

An online market is sometimes referred to as an electronic marketplace and is defined as an e-commerce site where producers can sell their products or services (Hendricks, 2020). Online channels are one of the biggest market channel trends seen globally. Due to the 2019 COVID global pandemic, minimal human contact has become the norm, leading to increased online platform sales. Global online sales increased by 90% in 2020 compared to 3.4% in 2019 (Fernandez, 2021). The online share of total sales is still relatively small in most parts of the world. However, the share is expected to grow significantly over the next 10 to 15 years, reaching around 7% globally by 2030 (Golightly, 2018).

The Freshlinq Platform is one of the online market channels platforms used by potato producers in South Africa. The Freshlinq Platform adheres to the definition of an online market. It facilitates transparent marketing system transactions between the producer and buyer of fresh produce. Freshlinq provides producers, agents and buyers with an online cloud-based platform that facilitates produce trade. The produce is directly sent to the buyer once the transaction is concluded. Freshlinq was initiated by a group of producers and market agents in June 2010. The goal was to evaluate the feasibility of an online trading platform for fresh produce which utilises the commission-based agency model that NFPM use but with lower commission fees of 2.75% for the agency and 1.25% for the market, in the online market case Freshlinq, as the infrastructure and overheads are less than those on a NFPM. The flow of funds through the Freshlinq model, as seen in Figure 2.9, adheres to legislation set out in Act 12 of 1992. The money flows from the buyer to a single joint trust account held by both Freshlinq (market) and the service provider (agency). The funds accrued to a specific producer of the produce sold is then paid over to the producer within five days.

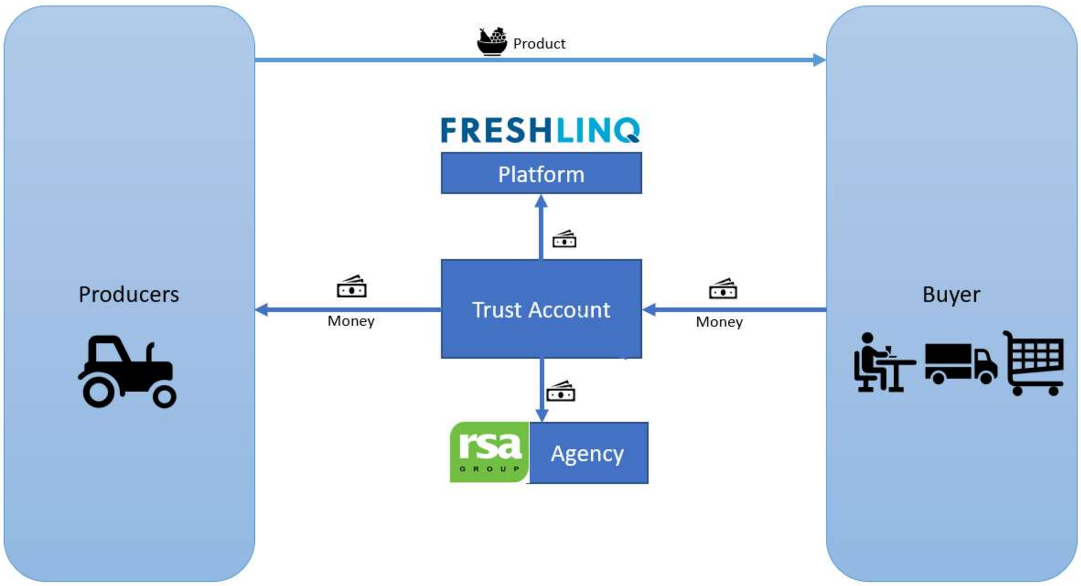

Figure 2.9: Freshlinq business model

Source: Freshlinq (2019)

Freshlinq not only facilitates online markets but also owns and manages private NFPM. These markets include Mooketsi, Nelspruit, Vereeniging and Polokwane market. Figure 2.10 shows the monthly prices received by producers on the Freshlinq online market and the percentage difference of NFPM managed by Freshlinq during the same period. The prices received on South African online markets are on average 4% higher than those on NFPM.

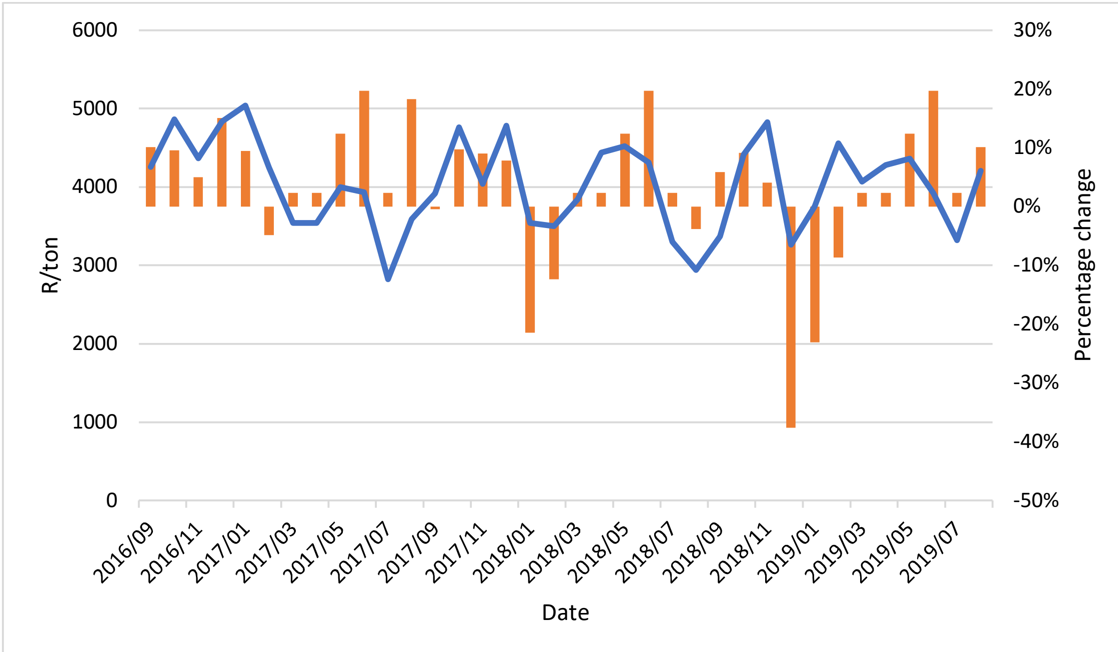

Figure 2.10: Monthly potato prices of online market from 2016 to 2019

Source: Freshlinq (2019)

2.4 MARKET CHANNEL ANALYSIS

Previous research on market channels analysis in agriculture shows predominantly two approaches. The first approach is a qualitative factor analysis that evaluates certain factors that affect a producer's marketing channel choice. The second approach is quantitative factor analysis, such as a profitability analysis of the different market channels.

A study by Umberger et al. (2015) conducted in Indonesia used the first approach on marketing channel choice evaluation. The study used Best-Worst (BW) scaling technique and latent-class (LC) cluster analysis to evaluate the market channel buyer factors preferred by potato producers. The data was collected from questionnaires via interviews with both producers and buyers in provinces that account for nearly all potato production in Indonesia. Respondents choose both the best (most important) and worst (least important) attributes, making trade-offs among subsets. The factors covered household, farm and marketing characteristics, including buyer attributes. For the LC cluster analysis, a covariation of observed preference scores of the BW scaling technique was used as a measure of utility to predict membership in a specific LC.

The LC cluster analysis results revealed that the sample's broad mass sought attributes of lower market risk for producers. Yet roughly a quarter of the sample, a portion that included farmers with large, specialised farms, sought buyers who could provide inputs such as high-quality seeds. The benefit of cluster analysis is that it is an unsupervised learning approach analysis that infers the relationship among variables rather than implying variable relationship and testing the magnitude as supervised learning does. The study, however, only provides groupings of factors and evaluates different market channel buyer factors rather than the market channel.

An example of supervised learning analysis is regression analysis. This type of analysis has been conducted in the agricultural space to highlight the factors that affect producers' market channel choice (Dessie et al., 2018, Musara et al., 2018, Nxumalo et al., 2019). Dessie et al. (2018) used primary data through a semi-structured questionnaire on market channel choices by wheat producers to identify the factors that affect the market outlet choice of wheat producers in Ethiopia. Dessie et al. (2018) used a multivariate probit regression model. It considered the interdependence between various market channels to quantify the influence of various factors on market channel choice, which other probit models such as the multinomial probit model do not consider. The results indicated that different factors affected the choice of different market channels. Additional regression analysis done on market channel choices (Musara et al., 2018, Nxumalo et al., 2019) used multinomial probit regression analysis as market channel choices were not interdependent. The factors affecting market channel choice for these studies were a combination of household demographics and market-specific characteristics. Musara et al. (2018) study compared three marketing channels, local, traders and a combination for Sorghum producers in Zimbabwe. The weighted average market price of sorghum, number of buyers in the market, distance to the market, dependency ratio and household income are the factors that affect marketing channel choice. Nxumalo et al. (2019), in a study, evaluated non-market participation, informal and formal markets as the market channel choices of sunflower farmers in South Africa. The results of Nxumalo et al. (2019) indicated that factors that affect market channel choice were age, marital status, gender, credit access, education, and farming experience. A study by Mabuza et al. (2014) analyses the effects of transaction cost on mushroom producers' choice of marketing channel in Swaziland. Marketing channels evaluated were farmgate, retail market, middleman and foodservice industry. To determine whether marketing decisions by mushroom producers were made simultaneously or sequentially, a likelihood ratio (LR) test was done on different regression models. The results of Mabuza et al. (2014) found that mushroom producers are more likely to make their marketing channel choice and quantity supplied sequentially. The results further showed that producers' decisions of where to sell their mushrooms are significantly affected by household labour endowment, production capacity, access to cooling facilities and market information, and producers' bargaining position. The quantities of mushrooms sold are significantly influenced by the difficulty accessing reliable transport and producers' level of uncertainty in meeting buyers' quality requirements. The factors that affect market channel choice for the studies by Dessie et al. (2018), Musara et al. (2018), Nxumalo et al. (2019) and Mabuza et al. (2014) do not have similar product or market channel types, and therefore the results cannot be compared.

One of the objectives of this study is to assess the profitability of different market channels. The studies performed by Umberger et al. (2015), Dessie et al. (2018), Musara et al. (2018) and Nxumalo et al. (2019) do not evaluate the profitability of the market channels in their respective studies. The second approach of market channel evaluation using quantitative profitability analysis is therefore of interest. Profit maximisation theory is a neoclassical theory of the firm that prescribes that a firm's objective is to maximise profitability. Profit maximisation is one of three assumptions under neoclassical economics. The other two assumptions are perfect information and people behave rationally (Weintraub, 2002). Profit maximisation refers to pure profits when all costs associated with production have been deducted. Assuming perfect competition, the biggest gap between revenue and cost is where marginal revenue (MR) equals marginal cost (MC). Figure 2.11 shows that if the firm produces less than Output of 5, MR is greater than MC. Therefore, for this extra output, the firm gains more revenue than it is paying in costs, and the total profit will increase. There is a slight increase in profit at an output of four as MR is only just greater than MC. However, after the output of five, the marginal cost of the output is greater than the marginal revenue. Therefore, the firm will see a fall in its profit level because these extra units' cost is greater than the revenue.

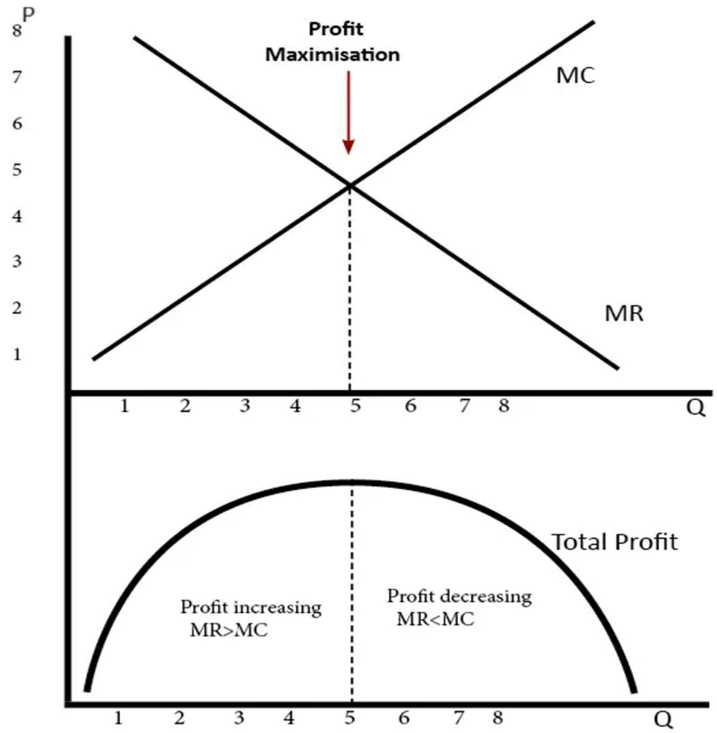

Figure 2.11: Profit maximisation under perfect competition

Source: Weintraub (2002)

There are numerous quantitative profitability approaches used in literature to evaluate market channels; however, only international studies could be found after an extensive literature review. One quantitative profitability analysis approach evaluates the revenue of different market channels (Feuz et al., 1993, Lee et al., 2020). Feuz et al. (1993) looked at the revenue of different price realisation for producers from four different marketing channels for slaughter cattle. The price formation of each marketing strategy is based on different methods that affect the prices realised by the producers. Results found that price discrimination led to greater revenue from one marketing channel to another. Feuz et al. (1993) evaluated that as one moves from one marketing channel to another, different information becomes available, and pricing accuracy improves. Lee et al. (2020) found the same results as Feuz et al. (1993) that different market channels generated different revenues. The objective of Lee et al. (2020) study was to examine whether the choice of different marketing channels, including sales to wholesalers, wholesale markets, and direct-to-consumer outlets by fruit and vegetable producers in Taiwan, affects farm revenue. The result indicated that wholesale marketing channels generate the most revenue for farms.

A different approach in evaluating the quantitative profitability of market channels uses net return or profit as the analysis method (Mehdi et al., 2019, Hardesty and Leff, 2010). A study that looked at producers' net returns based on marketing channels was done by Mehdi et al. (2019) in Pakistan. The study measured the factors that affected citrus producer's profitability given their choice in the marketing channel. Mehdi et al. (2019) used regression analysis with profit as the dependent variable and market participation as the independent variables. The results found farmers' profitability was positively affected by the participation in the modern marketing channels, i.e., run by the processors and contractors. Hardesty and Leff (2010) focused on the cost per returns associated with marketing channels. Data from case study farms in the U.S were collected for the study. The marketing-related activities were divided into packaging and storage, transportation and selling and administration. The study found that the marketing cost per dollar of revenue was lowest for wholesale farming and highest for farmers markets. Hardesty and Leff (2010) attributed this to the low labour to revenue ratio typically seen in the U.S wholesale markets. Using a net return or profit analysis compared to a revenue analysis enables the study of producer profitability back on the farm and not just revenue generated through the marketing channel. Revenue only incorporates the price and quantity sold and, therefore, evaluates the returns a market channel provides. Net return or profit analysis includes the deduction of cost that enables the analysis of the effect of a market channel back on the farm.

Profit maximisation theory is a theory that explains producer behaviour in the South African potato industry. However, the profit maximisation theory has strict assumptions that are not always possible in real life. The theory ignores the time value of money, assumes perfect information about price, cost and competition, and the theory ignores risk. Market diversification is a form of risk management that inherently aims to minimise risk while maximising profit. Therefore profit maximisation theory cannot exclusively explain the behaviour of market channel choice by producers. Transaction cost theory explains the basic principles of risk-minimising behaviour. Transaction cost theory was set out by Coase (1937) and is a theory in institutional economics. Coase's transaction cost economics theory states that firms exist because a firm's transaction cost is lower than those within a market. Essentially the theory describes that the lowest transaction cost has the highest performance, and therefore, the firm will always seek to minimise transaction cost. In a food marketing setting, transaction costs are all the costs associated with buying, selling, and transferring ownership of goods and services, including risk (uncertainty) (Jaffee, 1995). The profit maximisation theory states profit maximisation is the only behaviour that affects producers market channel choices. Just (1975) disproved that profit maximisation behaviour exclusively affects market channel choice. The study looked at the possibility of explaining risk management during profit maximisation behaviour of a firm. Just (1975) found that a firm can exhibit risk management behaviour while still exhibiting profit maximisation behaviour. Based on Just (1975) results, producers can be profit maximisers while considering risk. A study by LeRoux et al. (2009) evaluated profit and risk. LeRoux et al. (2009) used a detailed case study of four New York small farms to evaluate how risk, owner and paid labour, sales volumes, and profit interacts to impact the optimal marketing channel. This study differs from previous studies (Hardesty and Leff, 2010, Mehdi et al., 2019, Lee et al., 2020) as it incorporates risk into the analysis, among other factors. The profit ratio was calculated through the ratio of net returns, and sales in each marketing channel were evaluated. LeRoux et al. (2009) then compiled a ranking system that summarised all the evaluated factors per marketing channel and ranked the channels according to each factor performance based on individual firm preference. LeRoux et al. (2009) showed that Community Supported Agriculture (CSA) market channels, where producers get paid before the growing season for a share of production, were top-performing for dollars per gross sale, risk and marketing labour requirements, and farmers markets lowest performance and wholesales appearing in the middle. The study by LeRoux et al. (2009) evaluates most of the objectives this study has; however, it lacks the evaluation of market channel combinations and, therefore, different marketing strategies.

2.5 MARKET STRATEGIES FRAMEWORK

The analysis of market channels alone will not address the main objective of this study-to provide producers with a framework to compare marketing strategies. Diversification of market channels enables the combination of market channels to provide different marketing strategies to producers. After an extensive literature review on marketing strategies, only two studies were found that evaluated marketing strategies.

A study by Park and Lohr (2006) used regression analysis when analysing marketing strategies and evaluated the choice of marketing channels faced by organic producers through a discrete choice model. Park and Lohr (2006) evaluated the factors that affect producers' choice to use a specific marketing channel above and beyond pure profit. Park and Lohr (2006) developed a bargaining framework to identify a set of marketing channels based on an organic farming research foundation survey from all crops grown organically by producers. A multinomial logit (MNL) framework followed this to identify the factors influencing the choices. Park and Lohr (2006) then evaluated the MNL model results with an ordinary least squares (OLS) regression analysis looking at gross income earned based on different marketing channels as the dependent variable. The results found that producers with less experience tend to use a single marketing channel, whereas more experienced producers tend to diversify.

Kim et al. (2014) conducted a study that compared net returns of market channels and compared different combinations of market channels. The market channels were evaluated in terms of risk preference which provides producers with a framework to compare the marketing strategies from the varying level of market channel participation. The study used stochastic models to evaluate the strategic trade-off between higher prices and revenue uncertainty of USA farmers markets compared to the lower revenues but more predictable wholesale markets. The study's results were analysed using stochastic efficiency with respect to a function (SERF) and absolute risk aversion coefficients (ARAC) to rank each marketing option based on a producer's attribute toward risk. The results showed that marketing wholly to farmers markets was most attractive for risk-neutral producers. Risk-averse producers would prefer marketing 40% to farmers markets and 60% through wholesale channels. In the South African fresh produce industry, direct markets are equivalent to farmers markets and NFPM to wholesale markets in the USA.

2.6 CONCLUSION

Market channel diversification is a form of risk management that stems from transaction cost theory, which states that decreased transaction cost and risk (Coase, 1937) ensures higher performance in a firm. Market diversification not only focuses on decreasing risk but also maximising profit. Profit maximisation theory has some controversial flaws whoever Just (1975) proved that profit maximisation behaviour could occur simultaneously with risk management. To ensure adequate market channel diversification, market channel choice needs to be evaluated. The first approach is a qualitative factors analysis that evaluates certain factors that affect a producer's marketing channel choice. This study is interested in the profitability of different market channels and how the profitability's affect market channel choice. The studies performed by Umberger et al. (2015), Dessie et al. (2018), Musara et al. (2018) and Nxumalo et al. (2019) do not evaluate the profitability of the market channels in their respective studies. The second approach of market channel evaluation through quantitative analysis through profitability is therefore of interest. Using a net return analysis (Mehdi et al., 2019, LeRoux et al., 2009) compared to a pure profit analysis (Feuz et al., 1993, Lee et al., 2020, Hardesty and Leff, 2010, Park and Lohr, 2006) enables the study of producer profitability back on the farm and not just profit generated through the marketing channel. Market channel analysis on its own will not be able to address the main objective of this study to provide producers with a framework to compare marketing strategies comprising of different combinations of market channels. Kim et al. (2014) conducted a study that compared net returns of market channels and compared the combinations of market channels in terms of risk preference to provide producers with a framework to compare the marketing strategies from the varying level of market channel participation.

The international market channel analysis results showed that wholesale markets are more profitable than farmers markets (LeRoux et al., 2009, Hardesty and Leff, 2010, Lee et al., 2020). Risk analysis in these studies showed that wholesale markets are also less risky (LeRoux et al., 2009, Kim et al., 2014). South African fresh produce market channels are different to those used internationally, and it is difficult to evaluate or compare the results to a South African perspective. In the South African fresh produce industry, direct markets are equivalent to farmers markets and NFPM to wholesale markets in the USA. After an extensive literature review, no studies on the profitability and risk of online markets could be found. Therefore, this study will be the first to evaluate online market channels.

CHAPTER 3 : RESEARCH DESIGN AND METHODS

3.1 INTRODUCTION

Profitability is defined as the degree of financial gain of a business and its profit margin, operating profit margin and net return (Lee et al., 2020). There are numerous ways research has analysed net returns. Hardesty and Leff (2010) conducted detailed case studies of three producers to compare marketing costs and returns in alternative marketing channels. The results from the case studies research are accurate, but it lacks scientific rigour and provides little basis for generalisation of results to the wider population. Mehdi et al. (2019) used regression analysis to analyse the net return of different market channels with the net return used as the independent variable and the different marketing channels as the dependent variables. The study used the multinomial treatment effects model to capture the bias created by unobserved factors that affect a producer's choice of market channel. The advantage of multinomial over the ordinary least square is the explicitly model farmer's choice of a market channel. Unless included explicitly through a dependent variable, regression analysis does not inherently incorporate risk. Kim et al. (2014) used stochastic models in a study that compared net returns of market channels and compared different combinations of market channels. The market channels were evaluated in terms of risk preference which provides producers with a framework to compare the marketing strategies from the different combinations of market channels. Stochastic models, which incorporate risk into the analysis, are used in research when assessing production, profit, market and price risk in traditional agriculture (Curtis et al., 2014, Richardson et al., 2007a, Richardson et al., 2007b).

The research design and methods chapter describe how the study intends to answer the objectives and test the propositions. This chapter begins with a description of the type of analysis and tools the study will use, followed by a detailed description of the methods and procedures. It also serves to fulfil the scientific requirement of repeatability since it is a detailed guide to allow other researchers to replicate the study, whether in the same location or elsewhere.

3.2 DATA COLLECTION AND SAMPLE

The simulated net return for all the marketing strategies is the sample that this study further analyses. Each marketing strategies net return is simulated 1000 times which provides a probability distribution function (Kim et al., 2014). Net return is calculated by subtracting cost from income. There are two cost components, production cost and marketing channel cost. The variables that determine income are production and sales. Production is calculated through yield and area planted. Sales are calculated through the price received and the quantity of production sold. The quantity sold depends on the probability of sales and the combination of market channels. Each variable used in calculating net return is defined in Table 3.1. Constant variables only need one data point of actual data (Richardson et al., 2006a). Controlled variables are outlined by the study and define the different marketing strategies. The stochastic variables are based on actual data series, which is used to estimate the probability distribution parameters of the simulated stochastic variables. Data series with 10 or more data points provide accurate estimations (Richardson et al., 2006b, Richardson et al., 2006c). There are different methods to estimate the parameters which depend on the underlying data series distribution.

Table 3.1: Variable description

Variable Type	Description	Data points	Data Source
Constant variables	Area	1	
	Online marketing cost	1	Freshlinq (2019)
	NFPM marketing cost	1	Freshlinq (2019)
	Production cost	1	Potato SA (2020)
Controlled variable	Combination of market channel	11	Kim et al. (2014)
Stochastic variable	Yield	10	Potato SA (2020)
	Price online market	36	Freshlinq (2019)
	Price NFPM market	36	Freshlinq (2019)
	Probability of online market sales	3	Donnell et al. (2011)
Equations	Production		
	Sales Online		
	Sales NFPM		
KOV	Net Return		

Secondary data is used for this study's stochastic variables estimation and is collected from two different organisations. NFPM and online market prices are used from fresh potato sales on the Freshlinq platform. Freshlinq is a market facilitation platform and facilitates both NFPM and online markets. This study uses only one platform facilitator price data across both market channels to ensure reliable and comparable price data collected, processed, and formatted through the same platform system. The NFPM prices obtained from Freshlinq are from trade by RSA market agency in Mooketsi and Polokwane NFPM markets. These are the only two NFPM facilitated by Freshlinq operating during the period under investigation. Online market prices obtained from Freshlinq are from trade by Farm Fresh Direct market agency situated in Pretoria but trading nationally. Monthly price data for both market channels (NFPM and online) was obtained for three years, from 2016 to 2019. The price data obtained was net prices traded on each market channel and provided marketing channel cost for each trade. The marketing channel cost is a percentage of the net price and, based on the trade data, is 5% for online markets and 11% for NFPM markets.

Yield and production cost data for the potato industry was provided by Potatoes SA. Potatoes SA is the industry association supporting the potato industry within South Africa with research, information, marketing and transformation support. National yield data for 40 years was obtained however, only the last ten years are included in the analysis due to the substantial year on year yield increases. According to communication from Van Zyl (2020), these increases in potato yield result from technological advancements in cultivar development and using the entire series would have led to inaccurate yield representation and, therefore, net return. The potato production in South Africa is predominantly produced under irrigation, with only 25% under dryland production. The reason being why the national average production cost for potatoes under irrigation was used in this study for the 2019 season.

3.3 DESCRIPTION OF INQUIRY STRATEGY AND BROAD RESEARCH DESIGN

The data analysis method used in this study is stochastic simulation models and risk analysis. This study is defined as an empirical and quantitative study. Empirical studies are studies where observations (data) are analysed. This study used secondary data collected by other organisations. The secondary data was further analysed in this study. The objective of this study is measurable, and therefore the study is considered a quantitative study. The analysis of this study is completed using the Microsoft Excel add-in Simetar©, which is designed explicitly for agribusiness risk analysis and simulations analysis. Other programs such as MATLAB, R and Python are more statistical in nature. These programs do not incorporate or account for the unique distributions of agriculture production and the limited data the industry tends to have. Simetar© default uses different analysis that allows for and incorporates agriculture's uniqueness.

Simulation facilitates experimentation on real-world systems that cannot be tested in real life because they are too complex, have a long planning horison, or execute experimentation can endanger businesses profitability. Stochastic models are simulation models that include stochastic variables that are not known with certainty but have a probability distribution that is known or can be identified (Richardson et al., 2006a). Simulations are used to assist the decision-making of uncertain alternative strategies through incorporating stochastic variables and making control variable changes to estimate alternative strategies. Stochastic variables are incorporated into a simulation model through their estimated distributions. This study uses the yield, prices received from national fresh produce markets (NFPM) and online markets and the probability of online markets sales as stochastic variables. The control or scenario variables are the combination of different market channels which provide the marketing strategies. The stochastic and control variables are all incorporated in the net return equation, which is then simulated 1000 times for each marketing strategy. Simulation models only estimate the actual probability distribution for key output variables (KOV), which in this study is net return, but it will never be an exact estimation of reality. To ensure that the simulations are estimated as close to reality as possible, actual data is used during the estimate process with defined boundaries and assumptions.

Risk analysis is conducted by ranking the probability distribution of the marketing strategies using stochastic efficiency with respect to a function (SERF) approach developed by Hardaker et al. (2004). SERF combines the certainty equivalence (CE), created by Hardaker (2000), and the stochastic dominance with respect to a function

(SDRF) approach introduced by Meyer (1977) to provide a marketing decision-making framework based on profitability and risk. SERF allows for the simultaneous comparison of the marketing strategies and is therefore considered superior to other methods (Richardson et al., 2006a).

3.4 DATA ANALYSIS

The data analysis of this study has three phases:

1.) Stochastic variables probability distribution estimation
2.) Simulating KOVs
3.) Using SERF to determine risk preference
4.) Provide a framework

3.4.1 PROBABILITY DISTRIBUTION ESTIMATION

Before simulating the equations with stochastic variables, the probability distribution of the stochastic variables needs to be identified, as defined by Richardson et al. (2006c). There are two methods to identify the distribution of a stochastic variable. The first method estimates the probability distribution with parameters based on historical data, and the second is to infer the subjective probability distribution based on minimal input data.

The historic data for prices of the two market channels and the yield of potatoes was collected, and therefore these stochastic variables are subject to probability distribution estimations. The following two sections detail the estimation process.

3.4.1.1. DATA PREPARATION

The first step in data preparation is to graph the stochastic variables historical data. This enables the first-order identification of possible systematic variability such as trends or cycles in the stochastic variables.

The second step is to identify any trend (systematic variability) in the stochastic variables data series. This can be achieved with the initial steps of the approach designed by Richardson et al. (2006c) for data whitening with a trend. Ordinary least squares (OLS) regression with time as the dependent variable will identify a trend in a stochastic variable if the slope ($\hat{b}$) of the OLS regression is statistically different from zero through hypothesis testing at the ten percent level (Richardson et al., 2006c). The regression equation for a stochastic variable X with a linear trend is indicated in Equation 1, where T represents values for the years and $\hat{a}$ is the intercept.

Equation 1

$$X_i = \hat{a} + \hat{b}T_i \; for \; i = 1,2,3, \ldots n$$

Thirdly, a normality test should be run on the random variables to evaluate if the historical data has a normal distribution. This will guide the direction of estimating the parameters. Numerous normality test methods can be run on random variables. In this study, the Shapiro-Wilk test is used to test the hypothesis that the data is sampled from a normal distribution at the desired 95% confidence level. The Shapiro-Wilk test is the most appropriate method for smaller sample sizes with less than 50 values (Razali and Wah, 2011). The test statistic equation (W) is shown in Equation 2 where $x_{(i)}$ is the ith order statistic, $\bar{x}$ is the sample mean, x_i is the ordered sample values and a_i is constants generated from the covariance, variance and means of the sample from a normally distributed sample (Richardson et al., 2006c).

Equation 2

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n}(x_i - \bar{x})}$$

It is important to note that the variable itself may not be distributed normal, but the residuals about the trend regression will most likely be distributed normal and should also be tested for normality.

The fourth and final step is to check for correlation, meaning a statistical relationship between the stochastic variables with a correlation matrix. When the correlation between two stochastic variables is ignored in simulation, the model will either under-or-overestimate the variance and mean of the model outcome (Richardson et al., 2006d). The correlation coefficient (r) between two stochastic variables is calculated using Equation 3 where $\bar{x}$ is the sample mean of the x-variable, x_i is the sample values of the x-variable, $\bar{y}$ is the sample mean of the y-variable and y_i is the sample values of the x-variable (Richardson et al., 2006c).

Equation 3

$$r = \frac{\sum(x_{i-}\bar{x})(y_{i-}\bar{y})}{\sqrt{\sum(x_{i-}\bar{x})^2(y_{i-}\bar{y})^2}}$$

A correlation matrix summarises the correlation coefficient among and between the stochastic variables. A student t-test is used to test whether the population correlation coefficient (ρ) is statistically different from zero at the desired confidence level. The t-test is the most applied statistical hypothesis test when the test statistic follows a normal distribution (Richardson et al., 2006c).

The null hypothesis for the correlation t-test is that the population correlation coefficient is not different from zero. Therefore, there is no significant linear relationship/correlation between the stochastic variables. The alternative hypothesis states that the population correlation coefficient is different from zero, and therefore there is a significant linear relationship between the stochastic variables. The test statistic (t) can be calculated using Equation 4, where r is the sample correlation coefficient of the stochastic variables and n is the sample size (Richardson et al., 2006c).

Equation 4

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

For this study, a critical t value of 2.03 with a 95% confidence level is used as per the student t-test table (Appendix A). If the correlation coefficient t-test is significantly different from zero, which is indicated by a critical value that is smaller than the t-statistic, the variables must be simulated multivariate (Richardson et al., 2006d).

The online and NFPM preparation prices indicated no significant trend, normal distributions, and no correlation between the stochastic variables. Preparations for yield indicated a significant trend in the data series with normal distribution.

3.4.1.2 PARAMETER ESTIMATION

Before parameter estimation and subsequently random variable simulation, it is essential to correctly isolate the stochastic component from the deterministic component-separating the systematic variability from the random variability. This is achieved by whitening the data (Richardson et al., 2006c). Data series whitening is a decorrelation transformation that transforms random variables into a set of new random variables uncorrelated with unit variance (Eldar and Oppenheim, 2003).

There are three methods of data whitening that can be used for the stochastic variables. The first is regression analysis which should be used on data series that are non-stationary to identify the systematic variability. The second method is to calculate the deviations from the mean, which should be used when the data series is too short (less than ten observations) or when there is no systematic variability in the data series; therefore, it is stationary. The third method is first differencing of the data and moving averages which can also identify systematic variability (Richardson et al., 2006c).

This study uses method one for the two different market channel prices and method two for yield. The following section provides a detailed description of data series whitening for normal distributions of univariate stochastic variables established by Richardson et al. (2006c).

When the data series is distributed normally without a statistically significant trend or has less than ten observations withering using deviations of residuals from the mean is used. The deterministic component is the mean of the random variable. The stochastic component is the dispersion about the mean denoted by $\sigma_{\hat{e}}$ which can be estimated by calculating the standard deviation of the residuals about the mean is represented by Equation 5 and Equation 6

Equation 5

$$\widehat{e_i} = X_i - \bar{X}\ for\ i = 1,2,3,\ldots n$$

Equation 6

$$\hat{\sigma}_e = standard\ deviation\ of\ the\ \widehat{e_i}$$

The parameter for a normal distribution with a trend is indicated by NORM ($\bar{X}$, $\hat{\sigma}_e$) where $\bar{X}$ is the historical mean and $\sigma_{\hat{e}}$ is the standard deviation of residuals about the mean.

Therefore, stochastic prices are generated as detailed in Equation 7 and Equation 8.

Equation 7

$$\tilde{p}_j = \overline{p_J} + \tilde{v}_j$$

Equation 8

$$\tilde{v}_j = \hat{\sigma}_{ep_j} * NORM(0,1)$$

where $\overline{p_J}$ is the mean of the (historical) price, $\tilde{v}_j$ is the pure stochastic part or pure price distribution for the j^{th} market, *j*=Online and NFPM market and $\hat{\sigma}_{ep_j}$ is the residuals about the mean of prices in j^{th} market.

Stochastic variables that have a significant trend must be de-trended before parameter estimation can occur. Once a trend has been identified using step 2 of data preparation. The deterministic component is the random variable's trend regression defined in Equation 1. The stochastic component is the dispersion about the trend denoted by $\sigma_{\hat{e}}$ which can be estimated by calculating the standard deviation of the residuals from the trend

The parameter for a normal distribution with a trend is indicated by NORM ($\bar{X}$, $\hat{\sigma}_e$) where $\bar{X}$ is the historical mean and $\sigma_{\hat{e}}$ the standard deviation of residuals from the trend. Therefore, stochastic yield is generated as detailed in Equation 9 and Equation 10

Equation 9

$$\tilde{y} = \bar{y} + \widetilde{w}$$

Equation 10

$$\widetilde{w}, = \hat{\sigma}_{ey} * NORM(0,1)$$

where $\bar{y}$ is the mean of the (historical) yield, $\widetilde{w}$ is the pure stochastic part or pure yield distribution and $\hat{\sigma}_{ey}$ is the residuals from the yield trend.

3.4.1.3 GRKS DISTRIBUTION

The previous two sections used historical data to estimate the probability distributions and their parameters however historical data is not always available for stochastic variables. The stochastic variable, probability of online market sales, does not have historical data to estimate the probability distribution. Each trade on the online market only captures the amount sold and prices and does not indicate the total production of producers who sell potatoes on the online market. For this type of total production data to be analysed, case studies from all producers who trade on online markets need to be obtained, which is out of scope for this study.

GRKS distribution was developed by Gray, Richardson, Klose, and Schumann to enable probability distribution without historical data. The GRKS method simulates probability distributions subjective based on minimal input data. Estimates of three parameters, minimum, midpoint and maximum on a distribution of possible outcomes, is needed, and the GRKS will simulate a continuous probability distribution (Richardson et al., 2006b). The three parameters are used to estimate the remainder of the GRKS distribution parameters based on the properties of the GRKS. The GRKS distribution has the following properties: 50% of observations are less than the midpoint; 95% of the simulated values are between the minimum and the maximum; 2.2% of the simulated values are less than the minimum and more than maximum (Evans and Stallmann, 2006).

3.4.2 EQUATION GENERATION

A stochastic simulation model's primary goal is to estimate the probable outcomes for one or more KOV. The KOV is made up of numerous equations that consist of stochastic variables. The KOV is simulated many times using randomly selected values for the stochastic variables based on the probability distribution identified in the previous sections. The simulated sample of values for each KOV constitutes an estimate of the variable’s probability distribution which can be used to make decisions in a risky environment.

The studies stochastic variables are yield, price received from NFPM and online markets and the probability of online market sales as stochastic variables in the simulation model, with the KOV being net returns. This section provides a detailed description of the equations that make up the KOV as defined by Kim et al. (2014).

The first equation is production ($\widetilde{q_\imath}$) which is defined in Equation 11 where y indicates potato yield per hectare and a is the fixed planted hectares (the tilde on variables indicates stochastic variables).

Equation 11

$$\tilde{q} = a\tilde{y},$$

A fresh potato producer can choose the combination of the market channels (online market or NFPM). The combination of market channel participation gives the producer a choice between alternative marketing strategies. The marketing strategy determines the sales for online markets and NFPM defined by Equation 12 and Equation 13, respectively,

Equation 12

$$\tilde{s}_{Online} = \tilde{\theta}\alpha\tilde{q}$$

Equation 13

$$\tilde{s}_{NFPM} = (1 - \alpha)\tilde{q},$$

where $\tilde{s}_{online}$ is the level of potato sales in the online market channel, $\tilde{s}_{NFPM}$is the level of potato sales in the NFPM channel and $\tilde{\theta}$ denotes the probability of sales through online marketing, which is uncertain to the producer who decides the level of market channel participation (α). The market channel participation is distributed between 0< α<1 and is the decision variable in the model. The study uses eleven representative marketing strategy options as set out by Kim et al. (2014). Sending all potatoes produced through online market is shown by α =1 and α =0 is for the producer who sells exclusively on NFPM

- M1. All through online markets, i.e. $\alpha = 1$
- M2. 90% through online markets, 10% to NFPM, i.e. $\alpha = 0.9$
- M3. 80% through online markets, 20% to NFPM, i.e. $\alpha = 0.8$
- M4. 70% through online markets, 30% to NFPM, i.e. $\alpha = 0.7$

- M5. 60% through online markets, 40% to NFPM, i.e. $\alpha = 0.6$
- M6. 50% through online markets, 50% to NFPM, i.e. $\alpha = 0.5$
- M7. 40% through online markets, 60% to NFPM, i.e. $\alpha = 0.4$
- M8. 30% through online markets, 70% to NFPM, i.e. $\alpha = 0.3$
- M9. 20% through direct marketing, 80% to NFPM, i.e. $\alpha = 0.2$
- M10. 10% through direct marketing, 90% to NFPM, i.e. $\alpha = 0.1$
- M11. All to NFPM, i.e. $\alpha = 0$

The KOV net return (π) from marketing is given by Equation 14

Equation 14

$$\tilde{\pi} = \sum \tilde{p}_j * \tilde{s_j} - \sum M_j - C$$

Where $\tilde{p}_j$ is the price in the jth market channel as defined in Equation 7, $\tilde{s_j}$ is the sales in jth market channel as defined in Equation 12 and Equation 13, M_j is the marketing cost in jth channel and C is production cost. The jth market channels are Online and NFPM.

After the parameters are estimated and the equations set up, the KOV is simulated 1000 times to provide a probability distribution of net return for each marketing channel.

3.4.3 STOCHASTIC EFFICIENCY WITH RESPECT TO A FUNCTION

Each stochastic variable included enables risk to be inferred into the profitability of each marketing strategy, ensuring a realistic representation of real word net returns. The way producers perceive risk depends on their risk preference which affects their choice of marketing strategy as each strategy has different risks associated with it. Until this section, no account has been made for risk preference of the alternative strategies. Including risk analysis into the study enables the evaluation of risk preference of marketing strategy. Evaluating risky alternatives through preference can be done in several ways, but for this study, stochastic efficiency with respect to a function (SERF) approach developed by Hardaker et al. (2004) will be used. SERF combines the certainty equivalence (CE) approach, created by Hardaker (2000), and the stochastic dominance with respect to a function (SDRF) approach introduced by Meyer (1977).

The principle of the SERF approach started when Neumann and Morgenstern (1947) put forth the idea of using expected utility (EU) to rank risky alternatives. This was followed by Arrow (1965), demonstrating that the EU could be used to predict risky portfolio decisions. Pratt (1964) proposed absolute and relative risk aversion measures similar to Arrow. By the 1970s the EU was an accepted decision analysis tool.

The expected utility theory holds for SERF analysis that the decision-maker will pick the scenario which maximises utility however, in a simulation modelling context, we rewrite the utility function as defined in Equation 15

Equation 15

$$U(\pi_{Mi}) = U(\pi_{Mi}(\widetilde{X}, \alpha_{Mi}))$$

Where α represents the alternative strategies (Mi) control variable, the Z variables are the empirical cumulative probability distributions (CDFs) derived from the stochastic simulation model of the different strategies, and X is the stochastic variables.

The negative exponential utility function is the most commonly used utility function for SERF analysis, and its equation is shown in Equation 16

Equation 16

$$U(\pi) = 1 - exp\ (-r_a * \pi)$$

where r_a is the absolute risk aversion coefficient (ARAC) and can be calculated using Equation 17, where r_r is relative risk aversion coefficient.

Equation 17

$$r_a = \frac{r_r}{\pi}$$

Anderson and Dillon (1992) proposed a classification of r_r levels:

- 0 risk-neutral
- 0.5 hardly risk-averse,
- 1.0 normal or somewhat risk-averse,
- 2.0 rather risk-averse,
- 3.0 very risk-averse, and
- 4.0 extremely risk-averse.

SDRF proposes ranking risky alternatives (F(z) and G(z)) for a class of decision-makers, i.e., for decision-makers whose utility function is defined by a lower risk aversion coefficient (LRAC or r_1) and an upper-risk aversion coefficient (URAC or r_2) which is denoted as U(r_1 (z), r_2 (z)). The condition under SDRF is that F is preferred to G. The SDRF criteria indicates that utility is calculated for each z value, and the sum of the weighted utilities is used to rank F and G.

Hardaker (2000) proposed that any risky alternative's expected utility can be expressed through the inverse utility function as a CE. Freund (1956) defined the CE for a risky alternative as per Equation 18, where V is the variance of return

Equation 18

$$CE = \pi - 0.5 * r_a * V$$

SERF was developed by combining the principles defined by SDRF and CE and assumes a utility function with a risk aversion range of U (r_1(z), r_2(z)), but instead of evaluating CEs at the two extreme risk aversion coefficients (RAC), it evaluates CEs for many RACs between the LRAC and the URAC. Although SERF ranking is performed on many risky alternatives simultaneously, for simplicity, it is described in terms of ranking two alternatives (Equation 19).

Equation 19

$$F(\pi)\ preferred\ to\ G(\pi)\ at\ ARAC\ if\ CE_F > CE_G$$

$$F(\pi) indifferent\ to\ G(\pi)\ at\ ARAC\ if\ CE_F = CE_G, or$$

$$F(\pi)\ preferred\ to\ G(\pi)\ at\ ARAC\ if\ CE_F < CE_G,$$

where $F(\pi)$ and $G(\pi)$ are cumulative distribution functions of net returns from two risky alternatives and ARAC>0 (Hardaker et al., 2004). When ARAC=0, the decision-maker is risk-neutral and higher values of ARAC imply risk-averse decision-makers. SERF is superior to the approaches that preceded it and lead to its creation, as it allows for a comparison of all the alternative strategies simultaneously.

3.4.4 DEVELOPING A FRAMEWORK

A framework is defined as a basic structure underlying a concept which for this study is to enable potato producers of South Africa to compare marketing strategies. This is achieved by ranking the KOVs of each marketing strategy through different methods, each with its interpretation.

The following section evaluates five alternative ranking methods. The first method is the mean only rank, where the strategies are ranked from highest to lowest mean net return. The disadvantage of using mean only ranking is that the simulation's stochastic part is lost as the risk is ignored. The second method is the maximum method that ranks the highest maximum net return strategies to the lowest maximum net return. The disadvantage of this method is that it ignores the stochastic component of the simulations and the average net return for the strategies. This can lead to producers choosing a higher risk strategy known as a maximum error (Richardson et al., 2006e). The third method, MiniMax, attempts to minimise the chance of making a maximum error by ranking a strategy higher with the smallest minimum range between the mean and the minimum value. The disadvantage of this method is that it still does not consider the stochastic part of the simulation and can lead to choosing strategies with lower net returns than other strategies just because they have the smallest range. The fourth method is the coefficient of variation (CV) ranking, or relative risk ranking with the lowest CV considered the best strategy. The CV is defined as the ratio of the standard deviation and the mean and represents the relative risk associated with a strategy. This method is preferred to the last three as it considers the risk associated with each strategy however it ignores the skewness and extreme downside risk of the strategies. In the final method, SERF ranks alternative strategies for a specified range of risk aversion coefficients in terms of CE. The CE is the amount of money producers would accept rather than taking a chance on a higher but uncertain net return. Therefore, a higher CV is considered the best strategy for certain risk preferences. It is a preferred method of ranking as it considers risk preference and compares all the alternative strategies with each other

3.5 CONCLUSION

A stochastic simulation model's primary goal is to estimate the probable outcomes for one or more KOV to assist the decision-making of uncertain alternative strategies. The KOV for the study is the net return of online market and NFPM market channels made up of different equations that calculate income and cost. This study is an empirical study that used secondary data gathered from potato SA for yield and production cost and Freshlinq for market channel prices and cost to run a simulation model. Yield, price received from NFPM and online markets, and the probability of online markets sales are the stochastic variables that infer risk into the model to ensure an estimation that reflects reality. To avoid spurious results in simulation models, the correct parameters must be identified and used for the stochastic variables. The steps set out in this methodology's data preparation phase ensure that the correct approach is used when deciding on the parameters' distribution.

The simulated sample of values for each marketing strategies net return constitutes an estimate of the variable's probability distribution. Due to stochastic, each marketing strategy has incorporated risk. The way producers perceive risk depends on their risk preference which affects their choice of marketing strategy as each strategy has different risks associated with it. To evaluate the effect that risk preference has on marketing strategy choices, SERF developed by Hardaker et al. (2004) is used. SERF combines the CE approach, created by Hardaker (2000), and the SDRF approach introduced by Meyer (1977) of risk preference analysis. SERF is superior to other approaches as it allows for a comparison of all the alternative strategies simultaneously.

The simulated probability distributions of the net return are ranked through various methods to provide producers with a framework for comparing the net returns of different marketing strategies.

CHAPTER 4 : RESULTS AND DISCUSSION

4.1 INTRODUCTION

The previous chapter has detailed the methods of this study to evaluate market channel diversification for fresh potato producers through online markets and national fresh produce markets (NFPM). The main objective of this study is to provide fresh potato producers with a framework to compare marketing strategies comprising of different market channel combinations for online market and NFPM markets. The following propositions guide the study:

1: Fresh potato producers' profitability is higher for the online market channel due to lower marketing cost.
2: A fresh potato producer, who is risk-averse, will prefer to send most of their produce to the NFPM
3: Risk neutral potato producers will prefer to send most of their produce to online markets

The chapter first looks at the historical data's descriptive statistics and discusses the simulation and risk analysis results. The results are used to address the objectives and provide answers for the propositions.

4.2 DATA OVERVIEW

Historical data was obtained for the stochastic variables online market price, NFPM market price and potato yield. A summary of the stochastic variables' descriptive statistics is provided in Table 4.1. The descriptive statistics include mean, standard deviation and the minimum and maximum values. The online market prices have a higher mean and minimum value, than those of the NFPM during the period the historical data was obtained. It is in line with the expectations and knowledge of the markets. Both online and NFPM prices have high standard deviations - a measure of variation in a set of values (Richardson et al., 2006e), indicating a bigger movement from the mean. The results are in line with the volatility seen in spot market prices. This study is interested in evaluating the coefficient of variation (CV), which will indicate the spread of the data. The CV is a dimensionless number that compares the amount of variance between values whose scales of measurement are not comparable. The higher the variation from the mean, the higher the relative risk (Richardson et al., 2006e). The CV of potato yield is lower than that of both market channel prices, indicating a lower relative risk. Evaluation of the NFPM and online prices CV show higher variability for NFPM prices. The higher variability suggests less predictable revenues for producers but a higher profit ceiling, as confirmed by the maximum values seen in Table 4.1. Online market prices, which have lower CV's, theoretically should offer producers more stable and less risky revenues.

Table 4.1: Descriptive statistics of stochastic variables

	Yield (ton/ha)	NFPM Price (R/ton)	Online Market Price (R/ton)
Mean	43.68	3932.32	4035.92
Std Dev	2.45	587.93	564.46
CV (%)	5.61	14.95	13.99
Min	40.64	2759.14	2823.96
Max	47.13	5228.80	5037.50
Skewness	0.31	0.10	-0.22
Kurtosis	-1.84	-0.56	-0.72
Observations	10.00	36.00	36.00

Figure 4.1 and Figure 4.2 display historical data for the stochastic variables, yield and prices used for this study. These graphs form part of the study's data preparation phase and are a first-order evaluation of the stochastic variables to identify any possible systematic variability. Evaluations of these graphs suggest an upward trend in potato yield (Figure 4.2) and no apparent trend in online and NFPM prices (Figure 4.1). The trend seen in Figure 4.2 results from the technology advancements in potato cultivars that have facilitated higher annual yields, as Van Zyl (2020) communicated, the few dips in production were mainly attributed to droughts.

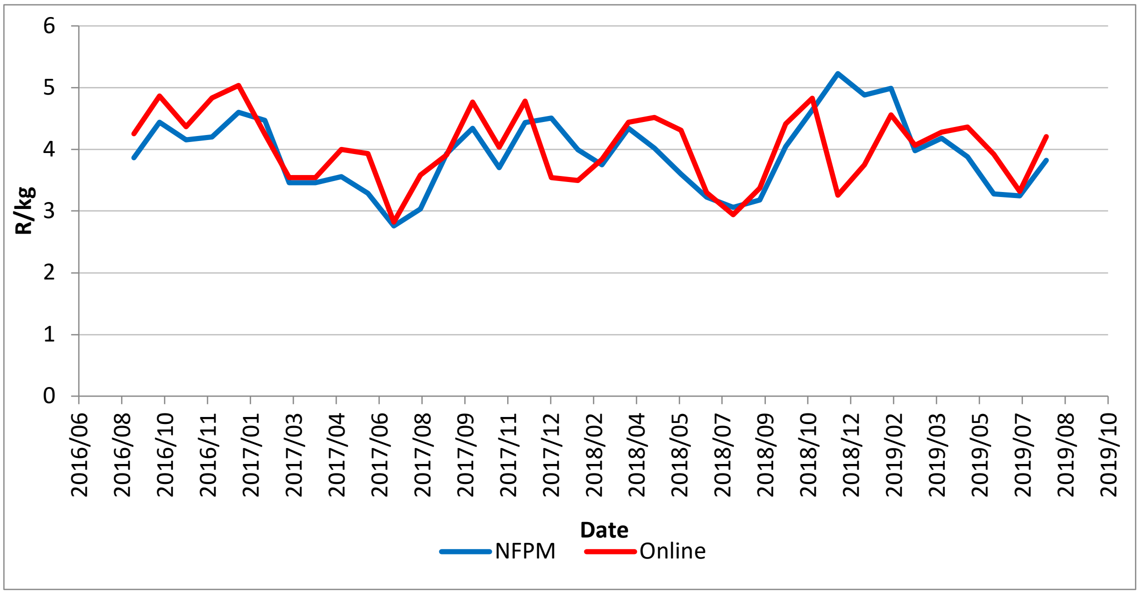

Figure 4.1: Online market and NFPM net producer prices

Source: Freshlinq (2019)

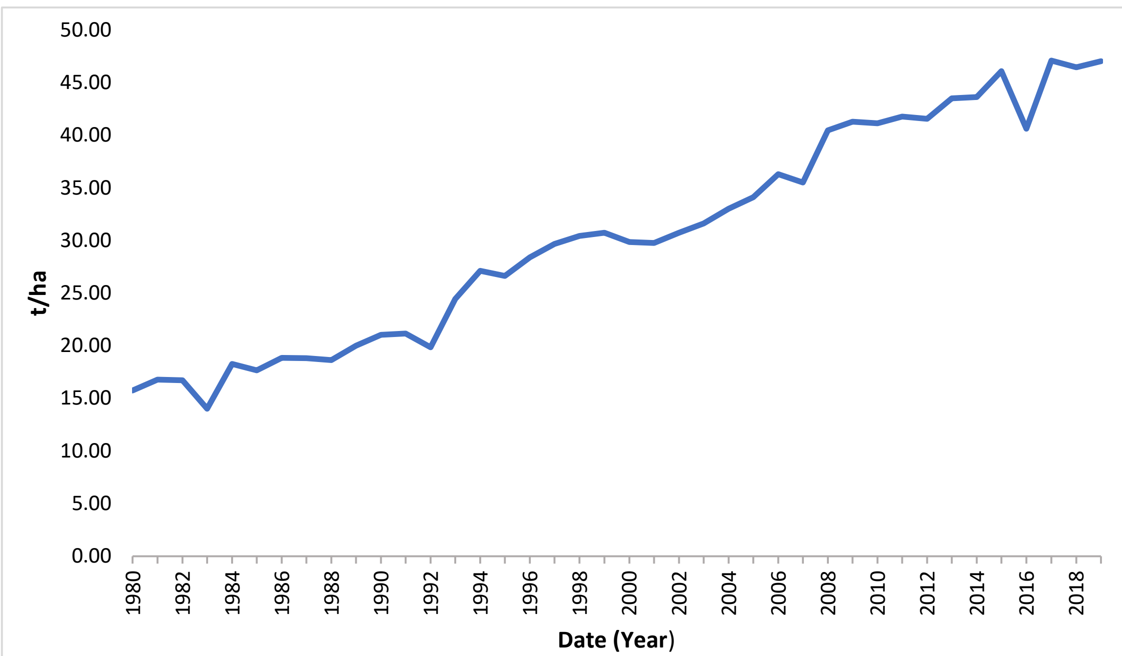

Figure 4.2: Historic yield 1980-2019 (t/ha)

Source: Potato SA (2020)

4.3 MODEL VALIDATION AND VERIFICATION

To ensure the key output variable will be simulated accurately, it is important to validate the simulation model by ensuring the stochastic variables are simulated correctly and demonstrate the expected properties of the parent distribution. The first step in model validation and verification is to validate the stochastic variables. Firstly, the study tests whether the means of the historical data and the simulated data are equal. This can be done using the univariate means test that uses a student t-test. The second step is to test that each simulated variable's variance equals the assumed variance used for the simulated variable, accomplished by a Univariate variance F test. The results of the t-test and f-test are shown in Annexure B. The stochastic variables yield, online market price and NFPM market price simulated means and variances equal their respective historical datasets. The second part of the validation and verification process is verifying the equations. The process can be completed by setting the model to expected value mode, so all stochastic variables equal their means. The results can be seen in Table 4.2 and indicate that the expected values are equal to the means. Production cost is excluded from this table due to a confidentiality agreement with the data provider.

Table 4.2: Models expected value

Description		Variable	Unit	Value
Constants	Area	α	ha	1.00
	Online marketing cost	M_{online}	% of Price	0.05
	NFPM Cost	M_{NFPM}	% of Price	0.11
Control Variable	Combination of market Channel choice	M1	%	1.00
		M2	%	0.90
		M3	%	0.80
		M4	%	0.70
		M5	%	0.60
		M6	%	0.50
		M7	%	0.40
		M8	%	0.30
		M9	%	0.20
		M10	%	0.10
		M11	%	-
Stochastic Variable	Yield	y	ton/ha	40.39
	Price Online	P_{online}	R/ton	4,536.68
	Price NFPM	P_{NFPM}	R/ton	4,181.75
	Prop. of sale Online	θ	%	0.85
Equations	Production	q	ton	40.39
	Sales Online	S_{online}	ton	34.18
	Sales NFPM	S_{NFPM}	ton	-
KOV	Net Return	$\prod$	R/ha	12,281.07

4.4 SIMULATION MODEL

This study's key output variable (KOV) is net returns of eleven marketing strategies comprising of different market channel combinations. The most profitable marketing strategy based on different combinations of market channels can be determined by simulating the net returns. Before simulating the equations with stochastic variables, the probability distribution of the stochastic variables need to be identified as defined by Richardson et al. (2006c). The probability distribution provides the boundaries and parameters that need to be inferred on the stochastic variables to represent the historical data accurately. Stochastic variables potato yield, NFPM market prices, online market prices, and the probability of online market sales parameters estimation preparation results, ordinary least squares (OLS) regression and Normality test are provided in Annexure A.

The parameter preparation results indicated that the stochastic variable potato yield is normally distributed with a trend. The OLS regression results on yield specified a p-value less than 0.1-at a 90% confidence level- indicating that the data has a significant trend over the historic period. According to the Shapiro-Wilk normality test, potato yield is normally distributed at a 95% confidence level with a p-value of 0.41, which is more than 0.05; therefore, failing to reject the null hypothesis that the data is normally distributed. The parameter for yield is therefore represented by NORM$(\bar{y}, \hat{\sigma}_{ey})$ where $\bar{y},$ is the mean of the historical potato yield and $\hat{\sigma}_{ey}$ is the standard deviations of the residuals from the yield trend.

Online and NFPM prices data preparation results indicated that these variables are normally distributed without a trend. The p-value of the OLS regression on online market prices and NFPM market prices is not less than 0.1 at a 90% confidence level, indicating no significant trend. The Shapiro-Wilk normality test results specify that the online market price and NFPM market prices are normally distributed at a 95% confidence level with p-values of 0.5 and 0.95, respectively. The parameter for online market prices is therefore represented by NORM $(\bar{p}_{Online}, \hat{\sigma}_{ep_{Online}})$ where $\bar{p}_{Online}$ is the mean of the historical online market prices and $\hat{\sigma}_{ep_{Online}}$ is the standard deviation of the residuals about the mean. The parameter for NFPM market prices is therefore represented by NORM $(\bar{p}_{NFPM}, \hat{\sigma}_{ep_{NFPM}})$ where $\bar{p}_{NFPM}$ is the mean of the historical

NFPM market prices and $\hat{\sigma}_{ep_{NFPM}}$ is the standard deviation of the residuals about the mean. The stochastic price variables did indicate a moderate correlation; however, a student t-test was run to evaluate if the correlation coefficient of the two variables is statistically different from zero. The t-statistic of 0.00 is less than the critical value of 2.03. The correlation coefficient, therefore is not statistically different from zero, and the variables are not considered correlated. The stochastic prices will therefore be simulated univariately

The GRKS distribution is assumed for the sales probability of online market. The sales probability is partially based on the approach used by Donnell et al. (2011) and refined in an interview conducted with van Zyl (2020) based on his insight and expertise within the industry. The study will presume the probability of online market sales is a minimum of 70%, a maximum 100%, with an average of 85%, GRKS (70, 85, 100). The GRKS distribution has the following properties: 50% of observations are less than the midpoint; 95% of the simulated values are between the minimum and the maximum; 2.2% of the simulated values are less than the minimum and more than maximum (Evans and Stallmann, 2006).

The stochastic variables parameters are included in the equations that make up the KOV which is net return. The net return in Equation 14 is simulated 1000 times to generate the probability distributions of net return for all eleven market strategies. Simulation models only estimate the true probability distribution for net return, but it will never be an exact estimation of reality. The probability distribution function (PDF) generated and shown in Figure 4.3 represents the simulated net returns of the market strategies. The figure provides producers with a simple visual answer of the possible values a certain market strategy can take, and the probability of the value occurring. Figure 4.3 demonstrates that strategy M1 has the lowest mean net return and the highest net return value of all the strategies. Strategy M11, however, shows the opposite to be true with the highest mean net return and biggest loss. The PDF provides a visual presentation and is good for comparison but lacks detail for informed decisions.

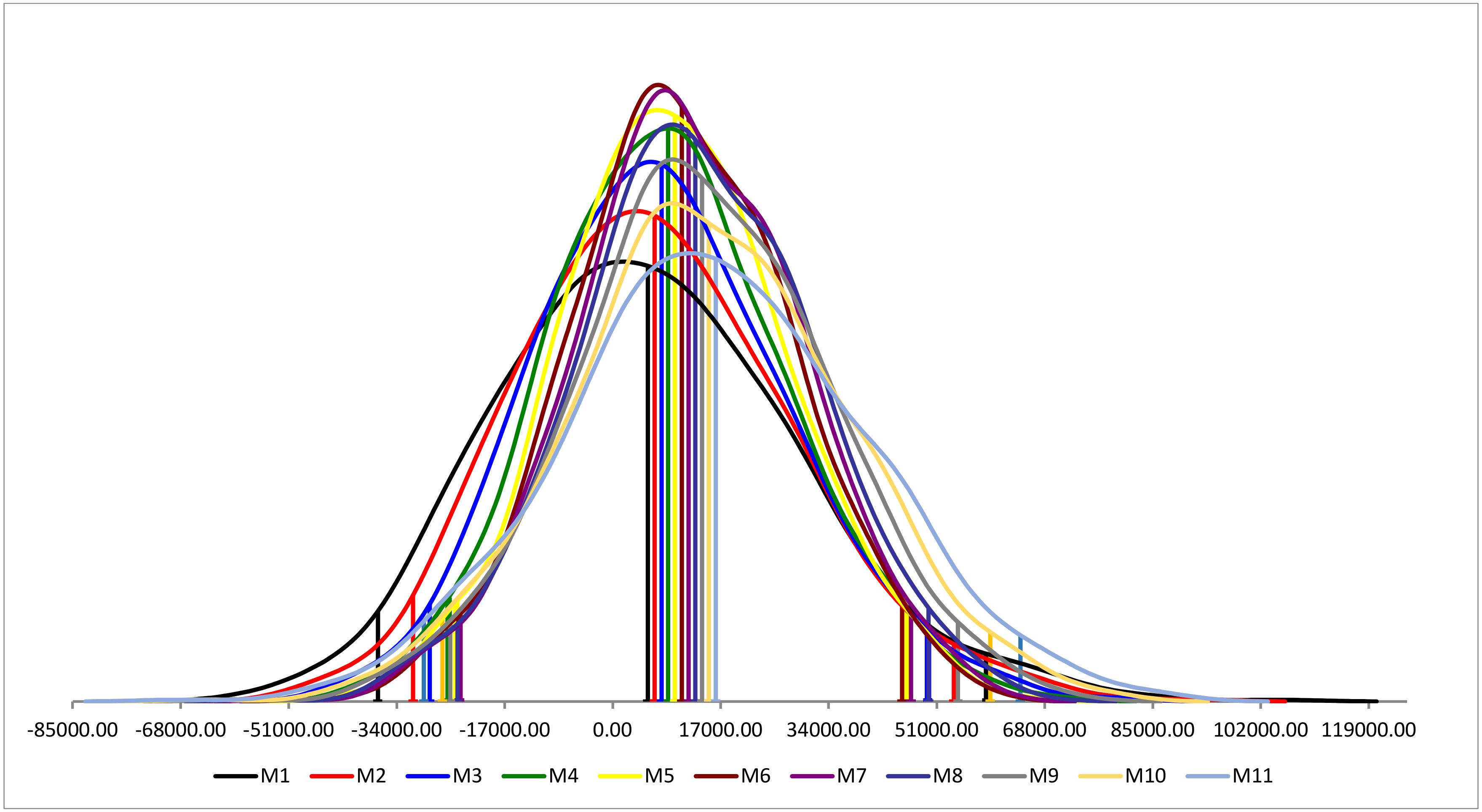

Figure 4.3: Simulated net returns probability density functions (PDF)

A summary of the net returns simulation results is given in Table 4.3 and provides producers with insights into each marketing strategy profitability to ensure informed decisions can be made. The deductions made from the PDF in Figure 4.3 are confirmed with the detail provided by Table 4.3. Market strategies M1 and M2 have the highest and second-highest standard deviations, indicating risky strategies. Market strategy M9 (20% to online market and 80% to NFPM) has the lowest coefficient of variation (CV) compared to the other strategies, which means it's the least risky marketing strategy.

A producer who sends all produce to online market (M1) has the possibility of earning the highest net return of all the strategies. This result confirms the first proposition of this study which proposed that fresh potato producers' profitability is higher for the online market channel due to lower marketing cost. This study also concurs with the finding by Hardesty and Leff (2010) and Kim et al. (2014) that lower cost associated with a channel leads to higher profitability.

Table 4.3: Summary of net returns from simulations (R/ha)

	Mean	Std. Dev	CV (%)	Min	Max
M1. All to Online	5,527.99	23,954.08	433.32	- 58,564.13	105,381.83
M2. 90% to Online and 10% to NFPM	6,594.81	21,780.07	330.26	- 51,518.43	92,642.58
M3. 80% to Online and 20% to NFPM	7,661.62	19,920.83	260.01	- 44,782.54	79,903.33
M4. 70% to Online and 30% to NFPM	8,728.44	18,471.66	211.63	- 41,022.60	70,731.86
M5. 60% to Online and 40% to NFPM	9,795.25	17,534.51	179.01	- 43,178.18	65,168.01
M6. 50% to Online and 50% to NFPM	10,862.07	17,193.33	158.29	- 47,433.43	59,618.13
M7. 40% to Online and 60% to NFPM	11,928.88	17,483.04	146.56	- 51,688.68	61,564.56
M8. 30% to Online and 70% to NFPM	12,995.70	18,373.82	141.38	- 55,943.93	67,820.24
M9. 20% to Online and 80% to NFPM	14,062.51	19,784.64	140.69	- 60,199.18	74,075.91
M10. 10% to Online and 90% to NFPM	15,129.33	21,613.92	142.86	- 64,454.43	80,331.59
M11. All to NFPM	16,196.14	23,765.21	146.73	- 68,709.68	86,605.35

4.5 RISK PREFERENCE ANALYSIS

Comparing the strategies based on mean, minimum, maximum, CV and standard deviations on its own can indicate the risk related to the sales strategies. It does however not include a producers' risk preference. This study used stochastic efficiency with respect to a function (SERF) to incorporate risk preference into the market strategies. Including risk preference into the analysis will enable the study to evaluate if the risk preference affects producers' marketing strategy choice.

This study used relative risk aversion coefficients (RRAV) suggested by Anderson and Dillon (1992). The RRAV includes a range from zero to four, where zero is risk-neutral, and four is extremely risk-averse. The average net return of all eleven market strategies is used when converting the RRAV to absolute risk aversion coefficients (ARAC) as set out in Equation 17. The ARAC ranges from 0 to 0.000368 therefore, a producer with an ARAC of 0 is risk-neutral, and a producer with an ARAC of 0.000368 is very risk-averse. Using the ARAC and certainty equivalent (CE), set out in Equation 18, SERF compares each marketing strategy based on a producers' risk preference. The CE is the net return a producer would accept rather than taking a chance on a higher but uncertain net return and varies over the producers ARAC. Figure 4.4 shows the output of SERF with the CE on the vertical axis and ARAC on the horizontal axis. In Figure 4.4, a producer would prefer the strategy with the highest CE at the various ARAC. The results of the SERF analysis indicate that an extremely risk-averse producer would prefer strategy M5. Strategy M5 includes sending 60% of production to online markets and the remaining 40% to NFPM as this strategy has the highest CE where ARAC is 0.000368. These findings reject the second proposition that a fresh potato producer, who is risk-averse, will prefer to send most of their produce to the NFPM as 40% of produce is not considered most of the producer's potato production. The results also found that a risk-neutral producer would prefer strategy M11. The strategy includes sending all potatoes to the NFPM as it has the highest CE where ARAC is 0. These findings reject the third proposition that risk-neutral potato producers will prefer to send most of their produce to online markets. Strategy M11 net return CV (Table 4.3) is lower than the other strategies, indicating a less risky strategy. Therefore, these findings indicate that a risk-neutral producer would prefer a less risky marketing strategy. These result does not align with findings made by Kim et al. (2014)

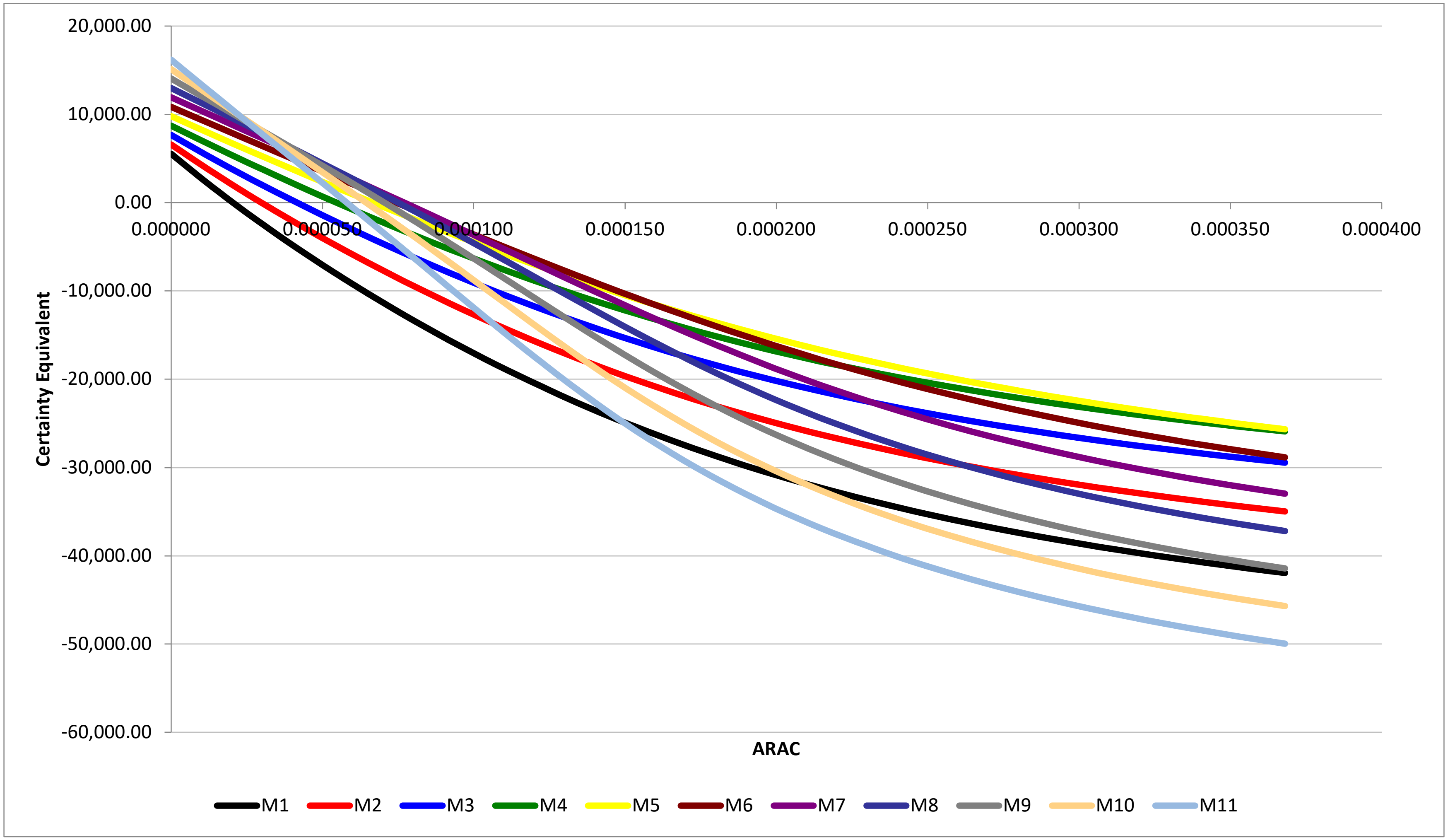

Figure 4.4: Stochastic efficiency with respect to a function (SERF) of simulated net returns

The SERF results show that risk preference changes the marketing strategy that producers would choose. Producers would not choose the marketing strategy with the highest net return, which Table 4.3 found is sending all produce to online market (M1). Considering risk preference, risk-neutral and risk-averse producers would rather send their produce to strategy M5 and M11, respectively.

4.6 RANKINGS

The finding from the simulation model (Table 4.3) indicates that a potato producer would choose to send all their potatoes to the online market (strategy M1) as the net returns are the highest for this marketing strategy. The preferred strategy changes when focusing on the mean net return (M11) or CV of net return (M9). The results suggest another strategy when incorporating risk preference (Figure 4.4). Given the changes in marketing strategy based on various evaluation methods, these methods need to be comparable to enable producers to make insightful decisions on the marketing strategy chosen.

The following section ranks five alternative ranking methods that form a framework to compare different marketing strategies. Table 4.4 summarises the results of five different methods ranked for the 11 market strategies. Numbers in the table represent a ranking with the various procedures for selecting the best strategy. Number "1" indicates the best strategy under each ranking method. The first method is the mean only rank, where the strategies are ranked from highest to lowest mean net return. Strategy M11 is the highest-ranked strategy based on the mean only method followed by M10 strategy. The second method is the maximum method which ranks the strategies from highest maximum net return to lowest maximum net return, with the best-ranked strategy being M1. The third method, MiniMax, ranks a strategy higher with the smallest minimum range between the mean and the minimum value. For this method strategy, M4 is considered the best strategy. The fourth method is the CV ranking, or relative risk ranking with the lowest CV considered the best strategy. The CV is defined as the ratio of the standard deviation and the mean and represents the relative risk associated with a strategy.

In the final method, SERF ranks alternatives strategies in terms of certainty equivalents (CE) for a specified range of risk aversion coefficients. Therefore, a higher

CV is considered the best strategy for certain risk preferences. This method considers 3 risk preferences: Risk-neutral when (ARAC =0), rather risk-averse (ARAC = 0.000184) and extremely risk-averse (ARAC = 0.000368). M11 is the strategy that risk-neutral producers would consider the best, whereas a risk-averse producer would consider M5 the best. M11, which risk-neutral producers prefer, may have the best mean ranking but has poor rankings for Minimax, indicating a big range between the values. M1 ranks poorly even though it has the largest maximum, it has the lowest mean and CV ranks, and all risk preferences have high number ranks for this strategy. Strategy M1 is the perfect example of a maximum error.

Table 4.4: Summary of rankings

					SERF		
	Mean	Max	MiniMax	CV	Risk Neutral	Rather risk Averse	Risk Averse
M1. All to Online	11	**1**	7	11	11	10	9
M2. 90% to Online and 10% to NFPM	10	**2**	4	10	10	7	6
M3. 80% to Online and 20% to NFPM	9	5	**2**	9	9	5	4
M4. 70% to Online and 30% to NFPM	8	7	**1**	8	8	3	**2**
M5. 60% to Online and 40% to NFPM	7	9	3	7	7	**1**	**1**
M6. 50% to Online and 50% to NFPM	6	11	5	6	6	**2**	3
M7. 40% to Online and 60% to NFPM	5	10	6	4	5	4	5
M8. 30% to Online and 70% to NFPM	4	8	8	**2**	4	6	7
M9. 20% to Online and 80% to NFPM	3	6	9	**1**	3	8	8
M10. 10% to Online and 90% to NFPM	**2**	4	10	3	**2**	9	10
M11. All to NFPM	**1**	3	11	5	**1**	11	11

Each ranked method recommends a certain strategy based on factors such as net return, risk or risk preference. Other aspects such as production skills, market access, and financial obligations can affect a producers' choice. The results in Table 4.4 therefore, provide a fresh potato producer with a framework to compare different marketing strategies.

4.7 CONCLUSION

The results discussed in this chapter have confirmed the first proposition and disproved the second and third propositions set out for the study.

The first proposition proposed that fresh potato producers' profitability is higher for the online market channel due to lower marketing cost. The results from the simulation model have shown that the highest possible net return for all eleven marketing strategies is the M1 market strategy, sending all of the producers' production to the online markets (Table 4.3). The M1 marketing strategy can provide a potato producer with net returns of up to R105 381 per ha.

The second proposition states that a fresh potato producer, who is risk-averse, will prefer to send most of their produce to the NFPM. The risk preference results indicated that an extremely risk-averse producer would prefer marketing strategy M5, sending 60% of production to online markets and the remaining 40% to NFPM. Production of more than 50% is considered a majority. Considering that 40% of production is less than 50%, this proposition is disproved. The third proposition states that risk-neutral potato producers will prefer to send most of their produces to online markets. The risk preference results found that a risk-neutral producer would prefer strategy M11 which sends all potatoes to the NFPM and none to the online markets.

Each analysis method indicated different marketing strategies as the preferred marketing strategy. To enable producers to make insightful decisions on the marketing strategy, the various analysis methods are ranked and provide producers with a framework for producers to compare marketing strategies. This study is the first of its kind in South Africa, after extensive literature review found no studies of its kind, and can also not be compared to international studies (Kim et al., 2014, Park and Lohr, 2006) due to the unique structure of the NFPM and online markets which is only found in South Africa (Jansen, 2017)

CHAPTER 5 : CONCLUSION

5.1 SUMMARY AND CONCLUSION

The national fresh produce market (NFPM) is the predominant market channel through which potato producers market their produce. NFPM is riddled with inefficiencies that have caused buyers and producers to move away from the market channel (NAMC, 2007, Lekgau, 2016). Producers who are still choosing NFPM as a marketing channel will see lower demand due to less buyers participating in the market channel. In the long run, decreased demand will lead to lower prices received by producers, which affects their profitability. According to Meyer (2020), a solution for producers to counter the effects of the NFPM experiencing decreased participation is diversifying market channels. South Africa has an online fresh produce trading platform. Online markets function similarly to the NFPM and are, therefore, a diversification option. Given the global movements and local online market structure availability, online markets are a viable market channel diversification option for potato producers.

Market channel evaluation is important to ensure effective market diversification. The first approach to market channel evaluation found from literature is a qualitative factors analysis that evaluates certain factors that affect a producer's marketing channel choice. This study is interested in assessing the profitability of different market channel combinations to evaluate the first benefit of market channel diversification which is increased profitability. The studies performed by Umberger et al. (2015), Dessie et al. (2018), Musara et al. (2018) and Nxumalo et al. (2019) do not evaluate the profitability of the market channels in their respective studies. The second approach identified through literature is market channel evaluation using quantitative analysis through profitability. The quantitative approach is therefore of interest. Using a net return quantitative analysis (Mehdi et al., 2019, LeRoux et al., 2009) compared to a pure revenue quantitative analysis (Feuz et al., 1993, Lee et al., 2020, Hardesty and Leff, 2010, Park and Lohr, 2006) enables the study of producer profitability back on the farm and not just profit generated through the marketing channel.

The second benefit of market diversification is decreased risk. Risk analysis needs to be executed for a complete quantification of market channel diversification. For producers, the involvement in online markets and NFPM markets presents a strategic trade-off between profit and risk. The way producers perceive risk depends on their risk preference (Pennings and Wansink, 2004). Simulation models incorporate risk into its analysis and are used to assist with the decision-making of uncertain alternative strategies. This is achieved by incorporating stochastic variables and making controlled variable changes to estimate alternative strategies. The purpose of this study is to provide fresh potato producers with a framework to compare marketing strategies comprising of different market channel combinations for online and NFPM markets. Therefore, the study will determine which marketing strategies are the most profitable based on different combinations of market channels. The study further aims to evaluate if potato producers' different risk preferences affect producers marketing strategy choice

The data analysis methods used in this study are stochastic simulation models and risk analysis. This study is an empirical study that used secondary data on the yield and production cost gathered from Potato SA and data on market prices from Freshlinq. Yield, prices received from NFPM and online markets and the probability of online markets sales are the stochastic variables. In order to avoid spurious results in simulation models, the correct parameters must be identified and used for the stochastic variables. The steps set out in this methodology's data preparation phase, ensure that the correct approach is used when deciding on the parameters distribution. A stochastic simulation model's primary goal is to estimate the probable outcomes for one or more key output variables (KOV). The KOV for the study is the net return of online market and NFPM market channels which is calculated through different equations that incorporate stochastic variables. The simulated sample of values for each KOV constitutes an estimate of the variable's probability distribution which can be used to make decisions in a risky environment. There is no inclusion of risk preference of the alternative strategies with just simulations. Risk preference analysis of alternatives strategies can be done in several ways, but for the study, stochastic efficiency with respect to a function (SERF) is used as it is superior to other approaches as it allows for a comparison of all the alternative strategies simultaneously.

This study's main objective to provide a framework for producers to compare marketing strategies is also accomplished by ranking the results from the simulation and risk analysis methods. The simulation model is used to test the first proposition that fresh potato producers' profitability is higher for the online market channel due to lower marketing cost. The results found that online markets are more profitable than NFPM markets; therefore, the proposition is confirmed. The second proposition states that a fresh potato producer, who is risk-averse, will prefer to send most of their produce to the NFPM. The results from this study's risk preference analysis disproves the second proposition and found that a risk-averse producer prefers to only send 40% of their potatoes to NFPM and not the majority of their produce. The third proposition proposes that risk-neutral potato producers will prefer to send most of their potatoes to online markets. The results from this study's risk preference found that risk-neutral producers will prefer to send all their potatoes to NFPM; therefore, the proposition is disproved. This study is the first of its kind in South Africa, after extensive literature review found no studies of its kind, and can also not be compared to international studies (Kim et al., 2014, Park and Lohr, 2006) due to the unique structure of the NFPM and online markets which is only found in South Africa (Jansen, 2017).

5.2 IMPLICATIONS OF THIS STUDY

This study contributes to the agribusiness literature stream and potato producers' managerial decisions. A handful of studies have been completed within the potato industry of South Africa. This study would therefore provide the industry with essential information by adding to the knowledge base on the profitability of the potato marketing channel and how risk preferences affect the marketing strategies. Online markets in South Africa are a relatively new marketing channel for producers in the fresh produce industry. The results of this study will assist and inform producers when choosing a marketing strategy. This study will provide information insights in a world where online markets are increasingly important

From an extensive literature review, information on the online market's profitability has yet to be analysed. No studies have been conducted to evaluate the dual market channel (online market and NFPM) as evaluated in this study. Therefore, this study would be the first study to investigate online market and NFPM profitability for potato producers in South Africa. The framework will assist producers in their farm management practices by providing a quantitative assessment of their marketing strategies based on personal risk preference and profitability. The framework enables the producers to be more insightful and make informed decisions on business profitability based on personal risk preference. This study will broaden the agricultural management knowledge base on marketing strategies and market channels. This study provides policymakers with a quantified risk assessment of alternative marketing strategies

Simulation models provide only an estimate of the true probability distribution of profitability, but it will never be an exact estimation of reality and therefore only stems as a guideline of possibilities

5.3 FUTURE RESEARCH OPPORTUNITIES

This study is an essential first evaluation of the current gap in the market strategies research for potato producers in South Africa. This study makes a novel contribution to the existing knowledge base, but improvement is possible. This study does not distinguish between production regions. This study used an average national yield and production cost. Different regions have different yields and different cost structures based on ecological factors that affect production practices and distance to markets. The NFPM prices only evaluated Mooketsi and the Polokwane NFPM as those were the only markets facilitated by Freshlinq during the period under investigation.

This study does not differentiate between producers in terms of small scale and large scale. Small scale producers and large-scale producers would not have the same cost structure assuming economies of scale, therefore, different types of producers would have different levels of profitability. There is scope for future studies to evaluate the profitability of potato production at a regional level instead of a national level and differentiate between producer types.

The research could also be extended to the other market channels (export and direct markets) within the potato industry. Due to minimal studies completed on the South Africa fresh produce industry, the study can be extended to incorporate other produce.

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ANNEXURE A

Table A.1: OLS regression statistics for yield

F-test	1356.963		
MSE$^{1/2}$	1.955		
R^2	0.973		
RBar^2	0.972		
Akaike Information Criterion	1.339		
Schwarz Information Criterion	1.381		
Prob(F)	0.000		
CV Regr	0.098		
Durbin-Watson	1.370		
Rho	0.277		
Goldfeld-Quandt	1.238		
90%	**Intercept**	**Yield Ton**	
Beta	**1965.729**	**1.110**	
S.E.	0.967	0.030	
t-test	2031.861	36.837	
Prob(t)	0.000	0.000	
Elasticity at Mean		0.017	
Variance Inflation Factor		NA	
Partial Correlation		NA	
Semipartial Correlation		NA	
Restriction			
S.D. Resids	1.905215	**MAPE**	0.078139

Table A.2: Test for normality of yield distribution

Confidence Level		95.0000%	
Procedure	Test Value	p-Value	
S-W	0.9719	0.4147	*Fail to Reject the Ho that the Distribution is Normally Distributed**
A-D	0.2921	0.5882	*Fail to Reject the Ho that the Distribution is Normally Distributed**
CvM	0.0363	0.7396	*Fail to Reject the Ho that the Distribution is Normally Distributed**
Chi-Squared	9	0.9734	*Fail to Reject the Ho that the Distribution is Normally Distributed**

**Based on approximate p-values*

Table A.3: OLS regression statistics for online market price

F-test	1.103		
$MSE^{1/2}$	346.272		
R^2	0.029		
$RBar^2$	0.003		
Akaike Information Criterion	11.693		
Schwarz Information Criterion	11.736		
Prob(F)	0.300		
CV Regr	0.803		
Durbin-Watson	0.049		
Rho	0.987		
Goldfeld-Quandt	0.978		
90%	**Intercept**	R/kg	
Beta	**43516.509**		-103.024
S.E.	400.198		98.077
t-test	108.737		-1.050
Prob(t)	0.000		0.300
Elasticity at Mean			-0.010
Variance Inflation Factor		NA	
Partial Correlation		NA	
Semipartial Correlation		NA	
Restriction			
S.D. Resids	337.276732	**MAPE**	

Table A.4: Test for normality of online market prices historic distribution

Confidence Level 95.0000%

Procedure	Test Value	p-Value	
S-W	0.973261	0.521098	*Fail to Reject the Ho that the Distribution is Normally Distributed**
A-D	0.293419	0.582443	*Fail to Reject the Ho that the Distribution is Normally Distributed**
CvM	0.043474	0.606618	*Fail to Reject the Ho that the Distribution is Normally Distributed**
Chi-Squared	5.888889	0.750985	*Fail to Reject the Ho that the Distribution is Normally Distributed**
			**Based on approximate p-values*

Table A.5: Correlation matrix of market channel prices

Linear Correlation Matrix

	NFPM	Online
NFPM	1	0.57
Online		1

Test Correlation Coefficients

Confidence Level		95.0000%
Critical Value		2.03
	Online	
NFPM	0.00	

Table A.6: OLS regression statistics for NFPM price

F-test	0.051		
$MSE^{1/2}$	324.768		
R^2	0.001		
$RBar^2$	0.000		
Akaike Information Criterion	11.565		
Schwarz Information Criterion	11.609		
Prob(F)	0.823		
CV Regr	0.753		
Durbin-Watson	0.010		
Rho	0.995		
Goldfeld-Quandt	0.994		
90%	**Intercept**	R/kg	
Beta	**43064.244**		20.749
S.E.	366.052		92.065
t-test	117.645		0.225
Prob(t)	0.000		0.823
Elasticity at Mean			0.002
Variance Inflation Factor		NA	
Partial Correlation		NA	
Semipartial Correlation		NA	
Restriction			
S.D. Resids	315.6174	**MAPE**	

Table A.7: Test for normality of NFPM prices historic distribution

Confidence Level		95.0000 %	
Procedure	Test Value	p-Value	
S-W	0.986303346	0.926709	*Fail to Reject the Ho that the Distribution is Normally Distributed**
A-D	0.168950851	0.933688	*Fail to Reject the Ho that the Distribution is Normally Distributed**
CvM	0.022612069	0.937104	*Fail to Reject the Ho that the Distribution is Normally Distributed**
Chi-Squared	4.166666667	0.900104	*Fail to Reject the Ho that the Distribution is Normally Distributed**
			**Based on approximate p-values*

ANNEXURE B

Table B.1: Results of student t-test and f-test

Yield

Confidence Level	95.00%		
	Test Value	Critical Value	P-Value
2 Sample t Test	0.30	2.63	0.767
F Test	1.82	1.84	0.053

Fail to Reject the Ho that the Means are Equal
Fail to Reject the Ho that the Variances are Equal

Summary Statistics

	Simulated	Historical
Mean	43.92	43.68
Std Dev	1.91	2.57
Min	37.20	40.64
Max	49.95	47.13
Skewness	-0.01	0.31
Kurtosis	-0.01	-1.84
SS Dev	3627.77	66.15
Observations	1000.00	11.00

Online Prices

Confidence Level	95.00%		
	Test Value	Critical Value	P-Value
2 Sample t Test	0.00	2.34	1.000
F Test	1.03	1.43	0.425

Fail to Reject the Ho that the Means are Equal
Fail to Reject the Ho that the Variances are Equal

Summary Statistics

	Simulated	Historical
Mean	4035.94	4035.92
Std Dev	564.63	572.46
Min	2171.54	2823.96
Max	5862.72	5037.50
Skewness	0.00	-0.22
Kurtosis	-0.02	-0.72
SS Dev	318490293.65	11469979.31
Observations	1000	36

NFPM Price

Confidence Level	95.00%		
	Test Value	Critical Value	P-Value
2 Sample t Test	0.00	2.34	0.998
F Test	1.03	1.43	0.428

Fail to Reject the Ho that the Means are Equal

Fail to Reject the Ho that the Variances are Equal

Summary Statistics

	Simulated	Historical
Mean	3932.02	3932.32
Std Dev	588.72	596.27
Min	1708.64	2759.14
Max	5790.77	5228.80
Skewness	-0.02	0.10
Kurtosis	0.03	-0.56
SS Dev	346243664.58	12444018.88
Observations	1000	36