Essays on climate change adaptive capacity measurement, trade-offs and benefits in South Africa's peach and nectarine fresh fruit trade

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DECLARATION

I, Chiedza Zvirurami Tsvakirai, declare that:

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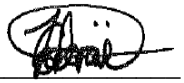
Signature 

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PUBLICATION DECLARATION

The following publications (accepted, under review and submitted) form part of the research presented in this thesis.

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Signature

Date 22 November 2020

DEDICATION

This thesis was written in loving memory of my parents; Dr Tinomthy T. Tsvakirai and Mrs Emily Mafuta Tsvakirai.

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ABSTRACT

Essays on climate change adaptive capacity measurement, trade-offs and benefits in South Africa's peach and nectarine fresh fruit trade

By

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Production technologies' such as seeds have been essential to the measurement of climate change adaptive capacity. These have been used to measure this phenomenon at the production level of the agricultural value chain and provide inference on the sector's ability to mitigate the adverse effects of climate change. However, literature has been lacking in its characterization and analysis of the market's responses to adaptation. Shifts in the seed market with particular reference to seed traits or qualities that promote sustainable production and the traits which promote the satisfaction of consumer demands (i.e. eco-efficient value) have not been done. This thesis takes advantage of the traceability of peach and nectarine seed (i.e. cultivars) in the value chain that permeates from production through to the retail level to measure the cultivar-trait trends, the enabling consumer values, economic impact and market opportunities driving and resulting from the dynamic balance between these two seemingly opposing dimensions of the product value. This study is done because cultivar quality is a critical area of this highly differentiated industry as it is a key in determining production profitability, production feasibility, market selection, market access, consumer acceptance, price levels, and market share in international trade.

This thesis presents five manuscripts that unpack climate change adaptive capacity's measurement, trade-offs and benefits in South Africa's peach and nectarine fresh fruit trade. The first three manuscripts take a backward-looking approach that gives an account of past market changes. These provide an inventory of the cultivar characteristics that have been proliferated from 1956 to 2015 (Manuscript 1), measure the long-term trends of the types of product value that is provided through the dominant cultivar

characteristics (Manuscript 2) and determine the benefits of the provision of eco-efficient value proposition on exports (in Manuscript 3). A long-term view is used here as climate change is interpreted as an enduring and slow-occurring market distortion whose effects require calculations on product quality that utilize time series that goes as far back in time as possible. Hence, these manuscripts use the longest time series of the data available (measured in 20 year segments). The last two manuscripts take a forward-looking approach that attempts to provide information on the current status and recommendations for future industry actions. This is done by identifying the cultivars that can be used to market the eco-efficient value proposition (Manuscript 4) and determining the markets which demand eco-efficient value proposition as a strategy to market growth (Manuscript 5). This analysis uses a relatively shorter time series which considers only the cultivars that are currently in use and excludes cultivars that have been discontinued in order to provide practical recommendations.

Several research methods were used to analyze the market's adaptive response to climate change. These included trend analysis, factor analysis, the gravity model, multivariate analysis and market growth-share analysis. The thesis utilized cultivar description data from various national and international cultivar repository data sources, export data from the national deciduous fruit producers' organization, International Trade Centre's trade statistics and Word Development Indicators.

The study found that there was a general increase in the quality of cultivar traits which improved consumer satisfaction as well as sustainable production. However, an antagonist relationship was often observed between the cultivar traits that promoted the fruit quality with those that promoted sustainable production. Hence, trade-offs were observed between these two dimensions of product value. South African exports were found to be competitive in the global markets. However, the measured product value propositions did not contribute to the growth in export earnings. The study recommends that better communication of the superior export product's eco-efficient value propositions be utilized to increase market growth in the two-thirds of the market where it provided competitive positioning. This should be particularly applied the US and Canada market where consumers have a preference for the cultivar varieties which rank high in the provision of this product value. In addition, the product's ability to meet high-quality demands should be used as the main selling point demands in the Far East and Asian markets.

KEY WORDS: Innovation markets, Value chain analysis, International trade, Eco-efficient value, Product quality up-grading.

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ACRONYMS

ANOVA - Analysis of variance

ARC - The Agricultural Research Council

CPOV - Community Plant Variety Office

BCG - Boston Consulting Group

BFAP - Bureau for Food and Agricultural Policy

CES - Constant Elastic Substitution

DAFF - Department of Agriculture, Forestry and Fisheries

DFB - Deciduous Fruit Board

DPDC - Dominant Product–Dominant Country

DPM – Decision Portfolio Matrix

DPNC - Dominant Product–Non-dominant Country

FE - Fixed Effects

GDP - Gross Domestic Product

IMS - International Market Selection

IPCC - Intergovernmental Panel on Climate Change

IPS - Im, Pesaran and Shin

ITC - International Trade Centre

KMO - Kaiser–Mayer–Olkin

lbf - pound of force

LLC - Levin, Lin and Chu

LR - Likelihood Ratio

NAMC - National Agricultural Marketing Council

NPDC - Non-dominant Product–Dominant Country

NPNC - Non-dominant Product–Non-dominant Country

OECD - Organisation for Economic Co-operation and Development

PCA - Principal Component Analysis

PDO - Protected Designation of Origin

PGI - Protected Geographical Indication

POLS - Pooled Ordinary Least Squares

RBV - Resource Based View

RE - Random Effects

SADC FTA - Southern African Development Community Free Trade Agreement

SBU - Strategic Business Units

SDG – Sustainable Development Goals

SDSN - Sustainable Development Solutions Network

SEMA - Strategic Export Market Analysis

SPS - Sanitary and Phytosanitary standards

TBT - Technical Barriers to Trade

UAE - United Araba Emirates

UK - United Kingdom

UPOV - International Union for the Protection of New Varieties of Plants

USA - United States of America

USDA-ARS – United States Department of Agriculture–Agricultural Research Service

WCG - Western Cape Government

WWF - World Wide Fund for Nature

CHAPTER 1
Introduction

1.1 Background of the study

The United Nations Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC, 2007) defines "climate change adaptive capacity" as the ability of a human-environment system to adjust to, alleviate potential damages, take advantage of opportunities, and/or cope with consequences of climate variability and weather extremes. This definition was developed to comprehensively describe the type of capabilities that would be required and nurtured in order to overcome climate change; which has become one of the biggest challenges of the 21st century. The term has been applied to food production systems to capture an organisational entity's ability to cope with, adjust to, or recover from climate-related stresses (Tol and Yohe, 2007; Mitchell and Tanner, 2006; Tinch et al., 2015). According to Smit et al. (2001), researchers have found that the elements that enable adaptive capacity include economic resources, technology, information and skills, infrastructure, institutions, and equity. For agri-food value chains, in particular, production technologies such as seeds or cultivars, have been central to the measurement of climate change adaptive capacity. This indicator has been used to particularly measure the characteristics of adapted seeds, the level of adoption of adapted varieties and the ease of use (Yohe and Tol, 2002; Chapman, 2012). The use of technology data has been valuable to research in enabling researchers to make attribution inferences on the cause of the adaptive benefits and allowed the capturing of the context-specific nature of climate change adaptive capacity.

The use of adapted cultivars[1] has been a critical determinant of South Africa's peach and nectarine fresh fruit sector's growth and development. Adapted cultivars have enabled the geographical spread of production into areas with harsh environments and facilitated participation in premium markets due to the improvements in fruit quality (Pieterse, 2012). Thus, cultivar selection has supported adaptation to environmental stresses and varying levels of consumers' environmentalism (the concern for the environment with respect to one's utility and others' well-being). Huysamer (1997), claims cultivar selections that are adapted to both the production and market dynamics have enabled the industry to perform competitively and participate in lucrative international markets. Yet, researchers have not found ways to measure the gained adaptive capacity that captures the different production and market adjustments and make attributions to their ability to facilitate growth of exports or aid in the development of competitive market position in global markets.

[1] A cultivar of seed is defined as a production technology or a unit of reproduction of a flowering plant, capable of developing into another such plant. The fruit, tree and rootstalk that is produced from a particular cultivar are also referred to as cultivars in the fruit industry.

Using methods developed from consumer and international trade theory, the current study measures climate change adaptive capacity calculates its trade-offs with hedonic utility and estimates its benefit/cost to trade. It takes advantage of deciduous fruits' highly differentiated technology industry, which allows cultivars to be identified from the production stage of the fresh fruit value chain through to retail level, and determines the on- and off-farm adjustments to the environmental changes. According to Tol and Yohe (2007), such an account provides a comprehensive reflection of the adjustment to climate change. The study also investigates the long-run adaptive capacity in this industry. This is an important aspect to capture as a system's vulnerability to climate change is often gradual (Kingwell, 2006), and measurement of the longer-term change provides an unbiased narrative of changes in the industry.

1.2 Research Problem

The South African peach and nectarine fresh fruit sector has used cultivar selection strategies to adapt to the environmental and market dynamics resulting from climate change. Unfortunately, researchers are yet to devise a way to measure the adaptive capacity that has accrued from such strategies; therefore the benefit immanent in cultivar selection adaptive strategies remains unknown. One reason for this gap in empirical evidence is the lack of an inventory that details the type of characteristics that have been proliferated through the cultivar market. The stiffening competition on fresh fruit markets has often forced producers to abandon the sustainable characteristics and prioritize instead the delivery of a product that meets the tastes and preferences of the consumers, and meets the technical, phytosanitary trade regulations of international trade regulating authorities (Ndou, 2012; Olivier, Foure and Evans, 2006). Apart from producers' sense of responsible stewardship, there has not been a strong retail market-driven motivation for the proliferation of sustainable characteristics and this suggests that there is an imbalance of market forces. Hence, an inventory on the degree of interdependence and/or trade-off between market demands and characteristics promoting sustainable production is important in leading the investigations of the status quo on the provisions of a value proposition that encourages congruence in sustainable production and the meeting of consumers' varying environmentalism orientations. That is, the provision of an eco-efficient value proposition (Michelsen, Fet and Dahlsrud, 2006).

The absence of a comprehensive indicator of climate change adaptive capacity has made it difficult to accurately evaluate and monitor the industries that are making progress in building effective climate change adaptive capacity (Gagnon-Lebrunand and Agrawala, 2007). This implies that, at the policy level, it is difficult to ascertain progress on the achievement of Sustainable Development Goal 12 and 13, which call on nations to combat climate change at the production and consumption levels. Blanco et al. (2017) claims that the absence of such measures also contributes to the reluctance of governments to invest in climate-change driven adaptation interventions. According to Gomez-Echeverri (2018), if the identified

deficiency in measurement instruments persists, it will also be difficult to encourage countries that lag behind their efforts to encourage sustainable production and responsible consumption.

Environmental drivers such as climate change have been hailed as key factors of change explaining the evolution of agro-food systems (Blanco *et al*., 2017). Consequently, cultivar selection as a climate change adaptation strategy has played a role in determining the type of characteristics that shape competitiveness in global markets. However, the benefits of providing eco-efficient value in the international trade context remain unknown for South Africa's peach and nectarine value chain. It is crucial to investigate the benefits of providing eco-efficient value proposition as such an investigation could provide evidence which would encourage the adoption of sustainable production and/or provide motivation for the development of such technologies (Suleman, 2017).

Responses to environmental and market dynamics have presented opportunities that have impelled comparative advantages for industries in the global market (Brown *et al*., 2017; Ahammad *et al*., 2015). These have, in turn, altered the volumes and patterns of international agro-food trade as countries have realised growth in market segments through the eco-efficient properties in their goods and production systems (Chapman, 2012). Foreign markets are increasingly characterized by a growing proportion of green-sensitive consumers, who tend to reward firms that adopt ecological marketing practices and punish those that abuse environmental initiatives. Curzi et al., (2020) adds that agri-food regulatory standards addressing safety, quality and environmental concerns have increased substantially, triggering growing attention to their trade and welfare effects. However, it remains undetermined if there are any gains/losses in trade earnings that have been experienced or opportunities that can be exploited using the eco-efficient value proposition provided in South African fresh peach and nectarine exports. The current strategy, which is aimed at acquiring premium prices through the off-peak market supply of fruit, is significantly threatened by fluctuating lengths of the Southern Hemisphere harvest season owing to climate change. Therefore, it remains to be determined if the existing strategy still provides a competitive market position for the sector or if the supply of eco-efficient value presents more opportunities for growth.

1.3 Research Objective

In light of the highlighted gaps in literature, the study aims to:

- Provide an inventory of the cultivar characteristics that have been proliferated by cultivar selection strategy. This is done in order to investigate the co-existence or trade-off between cultivar characteristics that promote sustainable production and non-environmental characteristics in the cultivars used for South Africa's peach and nectarine industry's fresh fruit exports.

- Measure the level of climate change adaptive capacity in South Africa's peach and nectarine industry's fresh fruit exports across time,
- Determine the gains in export volumes resulting from the provision of an eco-efficient value proposition in South Africa's fresh peach and nectarine trade,
- Identify cultivars with an eco-efficient value proposition, and
- Identify lucrative markets that demand eco-efficient value proposition.

1.4 Research hypotheses

The study makes the following tentative statements:

- There is a trade-off between cultivar characteristics that promote sustainable production and the non-environmental characteristics in the cultivars that are used for the South African peach and nectarine industry's fresh fruit exports.
- There has been an increase in the South African peach and nectarine industry climate change adaptation capacity across time.
- The provision of an eco-efficient value proposition trade by South Africa's fresh peach and nectarine sector has resulted in an increase in export earnings for the sector.
- The majority of the cultivars used in South African peach and nectarine industry's fresh exports have an eco-efficient value proposition.
- The majority of South Africa's lucrative export markets for fresh nectarines and peaches demand an eco-efficient value proposition.

1.5 Theoretical framework

The current study is guided by the theoretical underpinnings of the Resource Based View (RBV) of the firm. This theory states that an organization's ability to meet the diverse and dynamic business environments' demands and adjust to different stresses is determined by an internally determined mix of resources, activities, capabilities, partnerships and arrangements it uses rather than external factors (Barney, 1991; Dhanaraj and Beamish, 2003; Stoian, Rialp and Rialp, 2011). The RBV explains that organizations use a bundle of various key resources and assets to address the needs of a changing environment in which they operate (Boehe and Cruz, 2010; Ipek and Bicakcioglu-Peynirci, forthcoming). In this study, the key resources refer to the group of cultivars selected for export. This is done because in the highly differentiated industries such the peach and nectarine industry, qualities of cultivars are key in determining production profitability, production feasibility, market selection, market access, consumer acceptance, price levels, and market share. According to the RBV, the ability to acquire an optimal mix of assets and exploit their unique characteristics results in the derivation of value propositions which

facilitate the achievement of superior market performance (Campos-Garcia et al., 2020; Barney, 1991). The RBV posits that competitiveness is gained when the selected assets are able to deliver on asset: value, rareness, inimitability and/or non-substitutability (Leonidas et al., 2013). The definition of cultivar (a production technology which is distinct, unique, true-to-type and stable) map well into the RBV framework's empirical asset indicators; thereby allowing for the application of this theory to the innovation market's analysis.

In conceptualizing the trade-offs and co-occurrences that may arise from capitalizing on sustainable production and satisfying consumer demands, this study uses Stern's theory of value (2000). According to this theory, consumers have different environmentalism values, depending on their egoistic values (values that cause people to focus on maximizing individual outcomes based on self-interest), altruistic values (values that draw people to act based on concern for the welfare of others) and biospheric values (values that stem from concerns of welfare of the environment). The study first tests these claims of increasing environmentalism (in Manuscript 1) by using cultivar characteristics to measure the increase in the three value orientations. It particularly looks at the relationship existing between the different components of environmentalism. The study posits increasing trends in non-egotistic value orientations and hence a subsequent increase in the articulation of these values in products exported. This conjecture is made is view of increase global demand for non-hedonic food traits. The study secondly constructs indices that measure how the three value orientations have been woven into long-term value propositions (in Manuscript 2) and further identifies the cultivars in the current technology portfolio which have the highest eco-efficient value proposition (in Manuscript 4).

According to Irwin, Hoffman and Lamont (1998), merging heterogeneous resources generates capabilities that enable an industry to adapt to changing market environments through improvements in production efficiency. As implied by the Linder hypothesis, Porter hypothesis and Ricardian theory of international trade, countries that have attained a relatively higher proportion of the relevant adaptive capacity technologies in their value chains have a trade advantage over countries that do not (Huang *et al*., 2011; Huang and Kim, 2017). The current study uses this theory (in Manuscript 3) to determine whether high climate change adaptive capacity has imputed a comparative advantage that has stimulated higher export earnings. This theorem has been selected because it captures the "double exposure" of the agricultural sector to climate change. Double exposure is a phenomenon that explains the market equilibrium that results in the interaction of both economic and climate-related shocks and stressors to an economic-system (O'Brien and Leichenko, 2000). According to O'Brien and Leichenko (2000), the double exposure culminates in a positive, neutral or negative end-game.

According to Tol and Yohe (2007), any system's ability to cope with the exposure and/or sensitivity depends on the degree to which it can exploit its innate (or developed) adaptive capacity. The applicability of this statement in the South African fresh peach and nectarine value chain is tested in Manuscript 5. As suggested by the RBV, resources and capability analysis is an appropriate starting-point for export market strategy formation (Knudsen and Madsen, 2002; Stoian, Rialp and Rialp, 2011). Thus, competitive advantage evolves by developing the firm's unique skills, resources and capabilities and then finding the best market-place for them. The current study posits that eco-efficient propositions provide opportunities for growth by utilizing the idiosyncratic characteristics, which are determined by value orientation of the consumers' demand in South Africa's different export markets. Porter's theory of competitiveness (1985) is used here to provide integrative approaches to study how product-innovation could provide new market offerings to strengthen their ability to respond to articulated customer needs.

1.6 Conceptual framework

The study's conceptual framework is illustrated Figure 1.1 below. The first value chain node of South Africa's fresh peach and nectarine value chain has breeders who develop cultivars to satisfy two broadly defined objectives: the provision of cultivars that promote sustainable production and those that meet consumers' demands for perceivable good quality fruit. According to these criteria, the characteristics which will be prioritised because of their ability to promote sustainable production are the cultivars' "chilling units" and their "growth habit". On the other hand, the characteristics prioritised when focusing on consumers' demands (and provision of hedonic value), are cultivars' "flesh firmness", "skin colour", "flesh colour", "fruit size", "off-season supply". The farmers, in the following value chain node, select cultivars with these criteria in mind to provide the highest returns to production. The middlemen (retailers and exporters) follow the same guidelines; however, their close proximity to the consumers sets a precedent for the meeting of consumer demand over sustainability demands. The middlemen provide products that are purchased depending on the varying bias towards egoistic, altruistic and biospheric value orientations. Given the demand-driven nature of this value chain, the information on the consumers' expectations tends to have a precedent over the type of characteristics that are provided in the end product.

As shown in Figure 1.1, climate change affects the value chain by reinforcing the importance of sustainable production and responsible consumption. In the first effect, climate change causes an increase in temperature and this particularly results in warmer winters. Thus, farmers are influenced to select cultivars with lower chilling unit requirements. The farmers would also adjust their farming enterprises by using various adapted production methods. In order to achieve fair returns on the adapted production methods, the farmers are also bound to select cultivars with an upright growth habit that allows for higher planting densities that would assist in increasing enterprise productivity. In the secondary effect, climate

change brings an awareness of the need for collective environmental and social stewardship, and this leads to an elevated bias towards biospheric and altruistic values by consumers. Hence, there is less of a trade-off between the selection of characteristics that promote sustainable production and consumer demands. The study posits there is a resultant general increase in export volumes and earnings. However, as value orientations differ between individuals, lucrative markets for this value provision is determined when considering the idiosyncratic differences with the different markets.

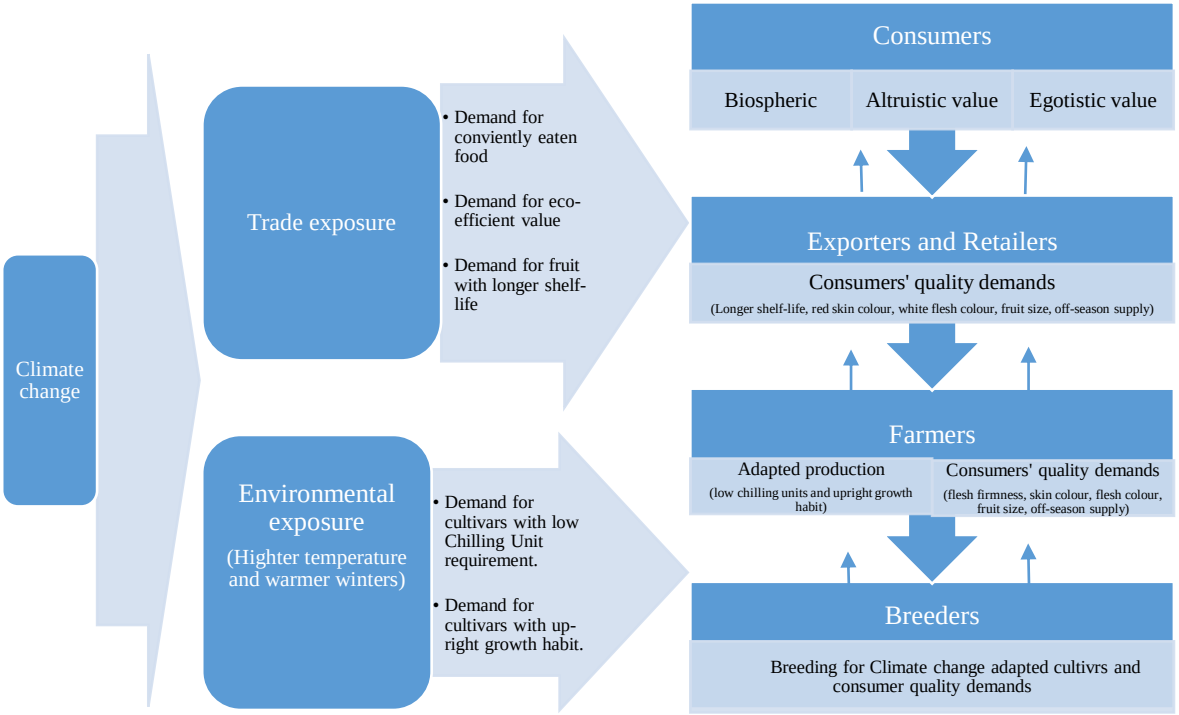

Figure 1.1: Conceptual framework

Source: Author's conceptualisation

1.7 Research methods

The thesis employs five analytical methods to analyse the five objectives specified in this study. These were utilised in Manuscript s 1 to 5 as follows:

1.7.1 Manuscript 1: Trend analysis

Manuscript 1 analyses the quality trends of peach and nectarine cultivars used for fresh fruit exports between 1956 and 2015. A long term view is used here as climate change is interpreted as an enduring and slow-occurring market distortion whose effects require calculations on product quality that utilize time series that goes as far back in time as possible. Hence, these manuscripts uses the longest time series of the data available (measured in 20 year intervals). Eight cultivar characteristics were considered as quality indicators in this study. These cultivar characteristics were "chilling requirement", "growth habit", "harvesting period", "flesh firmness", "fruit shape", "fruit size", "fruit skin colour" and "flesh colour". A three-point Likert scale was used to rank the attributes. A score of 3 implied that the cultivar was rated as having an excellent trait on the specific characteristic being measured, as this trait enabled the cultivar to

be aligned with existing and future market opportunities or production challenges in South Africa. A score of 2 implied that the cultivar was rated as having a good trait on the particular characteristic being measured, as this trait enabled the cultivar to be adapted to existing market opportunities or production challenges in South Africa. A score of 1 implied that the cultivar unsustainably met the production requirements, was acceptable for export use but the trait did not enable the cultivar to fare competitively with regards to addressing market and production demands of the prevailing age. Data availability, as well as interpretation feasibility informed the number of categories on the Likert scale. A three-point Likert scale was also used because it provides acceptable correlation coefficients in the analysis (Di Franco and Marradi, 2013). This method of analysis was used because of the variable form of the data (ordinal and scale) as well as the variable way the data provided in the different sources utilized. The current study follows the analogy provided by Groot and Albisu (2015), which ranked peach cultivar traits into three categories when investigating consumer preferences to the fruit's hedonic or organoleptic characteristics.

1.7.2 Manuscript 2: The Principal Component Analysis approach

The Principal Component Analysis (PCA) approach was used to reduce the number of cultivar quality indicators to comprehensive product value indices or Principal Components (PCs). The acquired PCs were weighted against the proportional use of cultivar for the period 1956 and 2015 to create indices that measured the various value propositions provided by the product across time. PCA is a suitable method for this analysis because it is an unbiased method that ensures that the attribution of each indicator in the composite index is based on the statistical behaviour of the underlying data, and not by preconceived notions of their influence (Moyer and Hedden, 2020). This approach has been used by other studies (Crisosto *et al.*, 2006; Cembalo and Guidice, 2009; and Kappel et al., 1996) that investigated the relationships between cultivar characteristics. Previous studies that have used this explicit weighting technique in constructing composite indices measuring sustainable development include Dahl (2012), Huan, Li and Lian (2019), SDSN (2013) and Nhemachena et al. (2018).

1.7.3 Manuscript 3: The Gravity model

Manuscript 3 uses the gravity model to determine the factors which stimulate or deter trade performance in the South African fresh peach and nectarine exports. This investigation utilises the gravity model which incorporates product quality characteristics, tariffs, and demographic, demand and economic indicators. It used panel data from South Africa and 21 trading partners for the period 2001 and 2017. It utilized all the international data available on the industry and all of South Africa's trading partners for the provide time series data. The paper utilised the indices derived from Manuscript 2 and data collected from the International Trade Centre (ITC), World Bank and HORTGRO as regressors of the multinomial regression model. The model possesses several distinct advantages over other comparable methodologies

of estimating bilateral trade flows. Firstly, the gravity model requires a relatively limited amount of data; hence, it can be estimated with parsimonious data in contexts where data is scarce and costly to obtain (Santeramo and Lamonaca, 2020; Erero, 2007). Secondly, gravity models have been improved over time to capture more robustly the theoretical considerations (Head and Mayer, 2014). Thirdly, the gravity models are able to estimate trade flows that reflect the influence of trade-enhancing and trade-inhibiting effects of various dynamic micro- and macro-economic factors (Kapuya, 2015). This is the key reason why the model is identified as one of the most useful empirical tools in estimating the cause-effects relationships between the identified factors and trade volumes.

1.7.4 Manuscript 4: The Multivariate analysis approach

Manuscript 4 used a multivariate analysis approach to identify the cultivars available in markets that demand for the eco-efficient value proposition. This analytical technique is a two-step method which utilized exploratory factor analysis and cluster analysis. The study extracted factors by using the principal axis factoring method from the cultivar data and export from 1997 to 2018. This data was accessed from national and international cultivar registries. This time period was used due to data limitations. A shorter data series was used only to capture the cultivars that are still used (exclude obsolete cultivars). The acquired factors were rotated using the varimax rotation method which maximises the variance (variability) within the derived Factors while minimising the variance between Factors (Di Franco and Marradi, 2013). This is different from comparable methods (e.g. quartimax) that minimise the variability within the Factors and achieve higher factor loading values. Deriving uncorrelated factors is instrumental for this study as this is a prerequisite for deriving market segments. The variables generated from the factor analysis were used to carry out cluster analysis. K-means cluster analysis was used to split cultivars according to the identified segments. This method allocates a set of individuals/observations to a set of mutually exclusive groups (Fraix-Burnet et al., 2015). The matching of the groups of cultivars with the market segments determined in the preliminary analysis was intended to draw inferences the industry's ability to serve the derived market segments. Cluster centre weights were used to determine the allocation of cultivars groups to different market segments. Analysis of variance (ANOVA) was used to detect significant matches between market segments and the clusters of cultivars.

1.7.5 Manuscript 5: The Dominant product-Dominant country approach

In the penultimate, Manuscript 5 used the Dominant Product-Dominant Country (DPDC) matrix approach to match the different product qualities to identify various growth opportunities in South Africa's global market. The simplicity of this method of analysis is one of its biggest strengths. The study utilized the data in Manuscript 4 to calculate product value indices which measured the strategic or competitive strength of the South African industry's product per market region. The analysis described the market for each product proposition per regional markets as belonging to one of the following categories: Dominant Product-Non-dominant country (High growth-high share), Dominant Product-Dominant country (High growth-high share), Non-dominant Product-Dominant country (High share-low growth) and Non-

dominant Product-Non-dominant country (low growth-low share). By so doing, the analysis identified lucrative markets for an eco-efficient value proposition provision. Examples of previous studies which have used product portfolio methods include Shankarmahesh et al., (2006) Fabry, Ernest, Langholz, and Koster (2006), Leonidas *et al*. (2013) Shankarmahesh et al., (2005) and Didenkoa Kunzeb, and Skripnukc (2015).

1.8 Definition of key terms

The following are some working definitions for this thesis:

Cultivar – A production technology that is used for a plant's reproduction (Layne and Bassi, 2008). It is produced by selective breeding and is a unique combination of traits which make it distinguishable from other cultivars. In deciduous fruit industry, the word cultivars is used to any part of the production technology, i.e. the seed, cutting, rootstalk, tree or fruit.

Cultivar characteristics and attributes – In this thesis, a cultivar characteristic is defined as an attribute that is used to descriptive of the fruit cultivar (e.g. fruit size or colour). This attribute is measured using subjective (large size) or ordinal (50 mm diameter) measures that provide ways of classification or differentiating varieties from each other.

Cultivar trait: In this thesis, a trait refers to the classification that each cultivar characteristic that results subjective or ordinal measurement. For example large/medium/small fruit or yellow/orange/red cultivars. This traits (classifications) are ranked in this thesis and scored based on the ability to meet production needs and consumer preferences.

Sustainable development target – This is an envisaged measure that is measured or to frequently monitored progress performance on the achievement of Sustainable Development Goals. The target is also referred to as an indicator in literature and certain parts of the study.

1.9 Study outline

This thesis consists of seven chapters. These chapters address the five objectives of the study, organised as follows:

Chapter 2 presents the overview of the South African peach and nectarine industry. It provides background knowledge of the industry and information on how it compares with other industries in the country and similar industries in the world.

Chapter 3 presents Manuscript 1. This sets the research scene by providing an inventory of the cultivar characteristics that have been proliferated from 1956 to 2015. It provides information that is critical for

the understanding of the thesis and it details the criteria used to determine the cultivar characteristics that were considered for this study, the measurement of each characteristic and the importance of each characteristic.

Chapter 4 presents Manuscript 2 and measures eco-efficient value proposition in South African peach and nectarine fresh exports in an index constructed from cultivar characteristic indicators. This index covers the period 1956 – 2015, and it is compared to the trends in the indices that do not have an eco-efficient value proposition.

Chapter 5 (Manuscript 3) is an empirical chapter that determines if there are any benefits to the provision of eco-efficient value proposition on exports. This incorporates the indices constructed in Chapter 3 as some of the regressors of a gravity model.

Chapter 6 (Manuscript 4) identifies the cultivars that can be used to market the eco-efficient value proposition. It uses the cultivars that have been in use in the industry for the past two decades and assigns the weight of the eco-efficiency to the cultivars.

Chapter 7 presents Manuscript 5 and determines the markets which demand an eco-efficient value proposition. It uses the weights calculated in Chapter 5 and determines indices that are specific to each marketing region. This is done in order to determine the industry's product positioning in each region's market. This analysis is undertaken to determine whether the strategy crafted around sustainable production and consumption could present better growth opportunities than the current strategy.

Chapter 8 wraps up the thesis by giving a summary of the key findings of the empirical chapters and draw conclusions based on how the different interrelations of the results of the different factors. It also details the limitations of the study and suggests areas for future research.

CHAPTER 2

OVERVIEW OF SOUTH AFRICA'S PEACH AND NECTARINE INDUSTRY

2.1 Introduction

This chapter aims to provide background on the peach and nectarine industry. It gives context to the thesis' empirical chapters by discussing the industry's origins, production distribution, and market dynamics. The central role of cultivar selection in these various dimensions of the industry is highlighted in order to bring an appreciation these production technologies in the industry. This discussion also provides an understanding to approach taken in the analysis of each empirical chapter. The chapter ends by explaining the link between sustainable production and discussed demands of the fresh fruit market.

2.2 Origins of the industry

Peaches and nectarines are originally from China where they were domesticated over 4 000 years ago (Layne and Bassi, 2008). Although peaches and nectarines are referred to as different fruits (for marketing and commercial reasons), scientifically they are the same fruit that is identified with the botanical name *Prunus persica* (Byrne, 2005). The only difference genetic difference between them is the fuzziness (hairiness) allele which differentiates peaches as the hairy fruit type while nectarines are the smoother type. Peaches and nectarines are classified as deciduous trees (trees that shed their leaves during winter) and produce their fruits on semi-hard, perennial trees (DAFF, 2010). Other fruit trees that fall under this classification include apples, pears, grapes, plums, apricots, cherries and prunes.

Peaches and nectarines were first planted in South Africa in 1678 and have been successfully commercialised (Black, 1947). In their early years of production, peaches served an early symbol of success in commercial agriculture as they were amongst the first successfully exports to leave South Africa to the United Kingdom in 1882 (Black, 1947). Similar to much of the world, peaches and nectarines have continued to be farmed for fruit production in South Africa. In other parts of the world, they are known as ornamental plants which produce attractive pink flowers (Byrne, 2002).

2.3 Peach and nectarine production

Peaches and nectarines are mainly grown in the West Cape Province which accounts for over 72% of the industry's annual production output (HORTGRO, 2019). Smaller quantities are produced in the Free State, Eastern Cape, KwaZulu Natal, Mpumalanga, Limpopo and North West provinces. The peach and

nectarine industry accounted for 8 686 hectares of the arable land in South Africa in 2018. The industry is a very important deciduous fruit industry and ranks amongst the largest in area planted. As shown in Table 2.1, the industry made up 12% of the total land area that was planted to pome fruits and stone fruits in South Africa in 2018. As indicated, the peach and nectarine industry accounted for the majority (49.5%) of this area planted to stone fruits in South Africa. This was equivalent to almost half of the area planted to stone fruit industries.

Table 2.1: Distribution of area planted to pome and stone deciduous fruits in South Africa

Deciduous fruits	Hectares
Pome fruits	
Apples	24 176
Pears	12 319
Stone fruits	
Peaches and nectarines	8 686
Plums	5 486
Apricots	2 737
Cherries	388
Prunes	260

Source: HORTGRO, 2018.

Note: Stone fruits are deciduous fruits that contain a single large seed encased within a tough outer shell Pome fruits are deciduous fruits that have a "core" of several small seeds, surrounded by a tough membrane

Peaches and nectarines can be propagated using seeds, however to in order to ensure the harvested fruit remains true-to-type, the trees propagated through cuttings (scions) (DAFF, 2010). This is particularly important for commercial production which is discussed and analysed in this thesis. Fruit market differentiation in the industry's reports is often done based on the colour of their skin (e.g. yellow peaches or red nectarines) or flesh (e.g. yellow-flesh peaches or white-flesh nectarines). Recent trends in marketing have encouraged the emergence of different ways of classifying the fruits into novel categories (Byrne, 2002). The traditional way of differentiated fruit in this industry has been by classifying it as either clingstone or freestone (DAFF, 2015). The clingstone fruits are those that have flesh that sticks on to the stone/seed of the fruit while freestone or dessert fruit types are those whose seed is not attached to the fresh. The clingstone (cling) fruit have firm flesh which allows them to have longer the flesh-life in the fresh fruit market and allows them to be used for agro-processing. Freestone fruits have melting flesh

and can only be used for fresh fruit sales (DAFF, 2015). In South Africa, clingstone types are mainly used for agro-processing (Pieterse, 2013).

A more common way of differentiating fruits is through the use of cultivars. A cultivar is a production technology that is used for a plant's reproduction (Layne and Bassi, 2008). It is produced by selective breeding and is a unique combination of traits which make it distinguishable from other cultivars and consistently provides a unique set of traits that are perceived to have value in the commercial agriculture. In deciduous fruit industry, the word cultivar is used to any part of the production technology, i.e. the seed, cutting, rootstalk, tree or fruit. The global peach nectarine industry has a large number of cultivars. The improvement of international intellectual property rights laws has facilitated the movement, use and development of these cultivars across boarder. It is difficult to accurately calculate the number of cultivars that have been used in the South African industry over the years because national tree-census reports have often reported the population of cultivars that account for more than 1% of the total production area or export season.

In the 1940s less than 10 cultivars were recorded in the peach and nectarine census. The number has grown to about 50 cultivar 2019. The number of cultivars that are utilised in the industry continues to rise because breeders have yet to develop cultivars that are able to capture all the important characteristics to gain a near-oligopolistic market structure (Byrne, 2005; Cirilli et al., 2016). This is different from other deciduous fruit industries such as the apple industry where there are a few prominent cultivars which have dominated the global market for decades (Byrne, 2002). The near-open market structure that is characteristic of the peach and nectarine technology market presents some limitations with regard to the exploitation of the financial rewards of breeding as there is much room for improvement in the fruit quality (Byrne, 2002). On the positive side, this market structure provides business opportunities for breeders as a new cultivar can easily out-perform and replace the existing cultivars. The large number of cultivars and the high replacement rate this is characteristic of this technology market (relative to other fresh fruit) makes this industry ideal for the analysis carried out in the current study. The industry's suitability is increased by the traceability of cultivars (from breeding laboratory to the retail shelf) that is possible in other agricultural industries (e.g. in the small grains industries). Understanding the dynamics in the cultivar markets is very important in this highly differentiated industry because it is the cultivars' unique combination of traits that determine production profitability, production feasibility, market selection, market access, consumer acceptance, price levels, and market share in international trade.

Table 2.2 shows the names and the percentage area planted to peaches dessert and nectarines cultivars during 2018. As shown below, a peach cultivar named Transvalia was planted to the largest land area recorded for dessert peaches while a nectarine cultivar called Alpine was planted to the largest nectarine production area in 2018. These cultivars took up 8.5% and 13.5% of the land area in their respective fruit type categories. As shown, there was higher concentration amongst the top-two nectarine cultivars as

compared to the dessert peaches. However, the proportion in area planted to one cultivar becomes almost equal when the top-five cultivars are considered. Cultivar concentration is an important indicator when analysing an industry because it presents opportunities for success in an optimist market where the cultivars with the largest market shares are performing well in the market. However, in a depressed market where the cultivars is becoming obsolete or fail to perform well due to production and market reasons, high cultivar concentration is risky to the industry.

Table 2.2: Percentage area planted to the top five dessert peach and top five nectarine cultivars

Dessert peach cultivars			**Nectarine cultivars**		
Cultivar name	Percentage of area planted to cultivar	Cumulative area planted to cultivars	Cultivar name	Percentage of area planted	Cumulative area planted to cultivars
Transvalia	8.5	8.5	Alpine	13.5	13.5
Summer sun	7.3	15.8	August red	7.6	21.1
Temptation	4.7	20.5	Royal ruby	2.8	23.9
Witzenburg	4.6	25.1	Super star	2.7	26.6
Ambercrest	3.9	29	May glo	2.7	29.3
Earligold	3.9	32.9	N47-13 (Luciana)	2.5	31.8
Fairtime	3.4	36.3	Fantasia	2.3	34.1
Cederberg	2.8	39.1	Sunburst	1.9	36
Sunsweet	2.8	41.9	Skye	1.7	37.7
Spring Princess	2.5	44.4	Tiffany	1.7	39.4
Excellence	2.2	46.6	Arctic Wolf	1.6	41
Novadonna	2.1	48.7	Sunlite	1.6	42.6
Other	51.3	100	Garofa	1.5	44.1
			Marget's Pride	1.4	45.5
			Crimson Glo	1.4	46.9
			September Bright	1.3	48.2
			Summer Fire	1.3	49.5
			Fire Pearl	1.3	50.8
			Garcica	1.2	52
			Summer Bright	1.2	53.2
			Other		46.8
Total hectares	**1 462ha**		Total hectares	**2 100ha**	

Source: HORTGRO, 2018

Note: Table only contains information of freestone peach cultivars.

2.4 Peach and nectarine industry value and fruit distribution in markets

The peach and nectarine industry employs 9 507 labourers that provide livelihoods for 38 030 dependents during 2017 (HORTGRO, 2018). The importance of the sector can also be assessed from its multiplier effects on the other sectors of the South Africa economy. Upstream the sector links primary agriculture with research institutes, input suppliers, co-operatives, banks and insurance companies, as well as a wide variety of farming models and products. The downstream it provides a thriving agro-processing sector (HORTGRO, 2012). In 2018, the industry had a gross value of over R1.2 billion (DALRRD, 2020). As shown in Table 2.3, most of the fruit was delivered to the agro-processors. This fruit was used to produce canned fruit, jam, purees, fruit juices and other refined products. The other remaining fruit was sold on the local fresh market, international fresh market or used to produce dried fruit. As shown, over the 2008-2018 period an average of 21% of the industry fruit was sold on the local fresh market, 7% was exported, 66% was used in canning and 6% was used to make dried fruit.

Table 2.3: Fruit distribution in the market

Year Oct-Sept	Total Production (ton)	Local Market (ton)	Exports (ton)	Processed (ton)	Dried (ton)
2008/2009	164 286	32 673	7 359	112 487	11 649
2009/2010	167 353	39 352	9 350	106 773	11759
2010/2011	171 104	42 627	8 815	108 912	10 293
2011/2012	191 673	45 585	11 388	125 706	8 905
2012/2013	184 051	40 675	11 209	121 539	10 522
2013/2014	155 864	33 938	11 301	102 347	8 195
2014/2015	211 610	37 287	14 314	146 148	13 723
2015/2016	204 894	36 618	15 582	137 733	14 812
2016/2017	199 106	37 580	15 730	132 464	13 200
2017/2018	163 170	39 188	15 940	97 720	10 263
Average fruit distribution		**21%**	**7%**	**66%**	**6%**

Source: HORTGRO, 2018

2.5 Peach and nectarine fresh exports

Figure 2.1 shows the export destinations for the fresh peaches for the 2017-2018 season. As shown the majority of the peaches were exported to the United Kingdom and the Middle East region which accounted for 42% and 39% of the exports, respectively. Smaller quantities were exported to Europe (10%), the Far East and Asia (2%), Africa (1%), USA and Canada (1%), and Russia (1%). The United Kingdom is the dominant export destination due to the presence of well-established trading ties (e.g. trade agreements) between South Africa and its former colonial mother-country. The relatively higher buying-power of the British Pound as compared to other currencies also provides an incentive for making this the preferred nation for export. The Middle East is also another attractive market because it does not have as many quality market restrictions as the Western markets (DAFF, 2015).

The introduction of a wide array of food quality and regulatory measures by the European countries and United Kingdom has increased the attractiveness alternative markets. Many of these measures fall in the category of sanitary and phytosanitary (SPS) measures and include diverse conditions such as import licences, inspection requirements, testing and certification requirements, labelling and packaging requirements, and quarantines (Murina and Nicita; 2017, Olivier et al., 2007). Strategic cultivar selection has played a critical role in aiding the participation global markets as certain cultivars have longer-shelf and allow exports to pass quality-checks with ease and thus enable the industry to continue to access the western, lucrative markets.

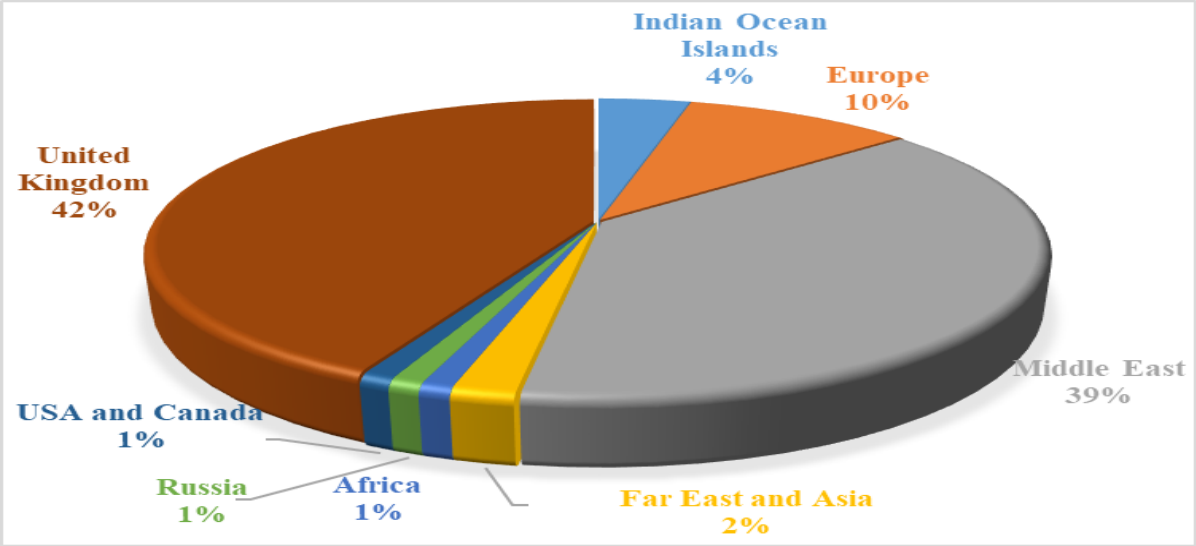

Figure 2.1: Distribution of fresh peaches in export regions

Source: HORTGRO, 2018.

Figure 2.2 shows the export destinations for the fresh nectarines for the 2017/18 season. Similar to the distribution of fresh peaches, the United Kingdom is the main export destination for fresh nectarine sales. There are some interesting differences that can be observed in the two markets. The market share for nectarine exports in the Middle East is less than the market share for fresh peach exports (15% as opposed to 39%). On the other hand, the market share for nectarine exports in the European market is higher than the share for peach exports (23% as opposed to 10%). This export distribution could be because the nectarines are the premium product in this industry and are exported to the most lucrative markets. The market share of the remaining three regions (Russia, Africa and Far East and Asia) remained with the 1-2% market-share size range. Significantly different from the fresh peach exports, the market share of USA and Canada decreased to below 1% while the market share for Indian Oceanic Islands increased to 1% in the market analysis of the fresh nectarine exports.

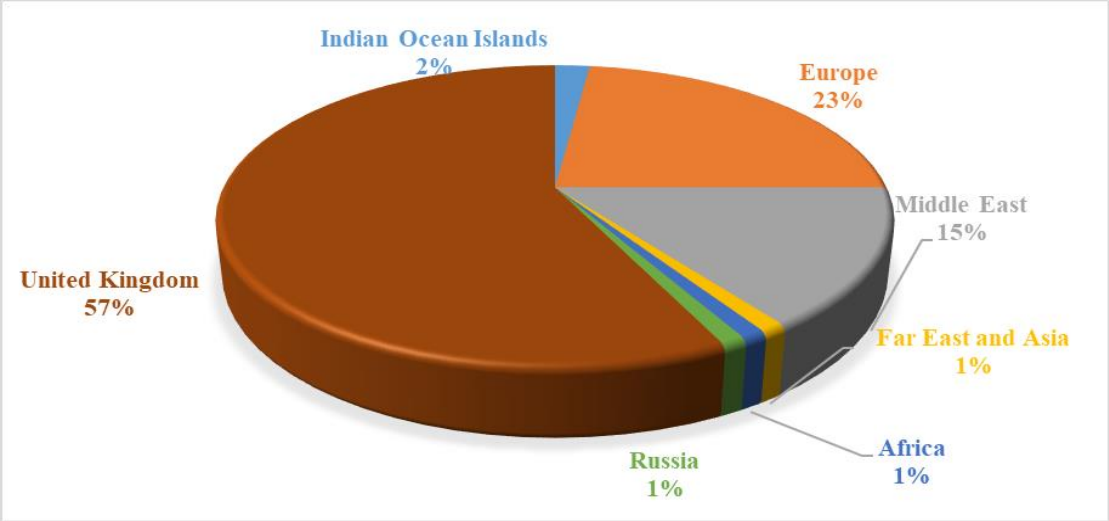

Figure 2.2: Distribution of fresh nectarines in export regions

Source: HORTGRO, 2018.

2.6 Competition in the Southern Hemisphere for lucrative global markets

The fresh fruit harvest period for South Africa stretches from September (week 38) to May (week 14). South Africa shares this 4th-quarter-to-1st-quarter harvest season with its Southern Hemisphere counterparts: Argentina, Chile, Brazil, New Zealand and Australia. This means that these are the competitors of South Africa in the global market as these countries share marketing period as dictated by the global seasonal shifts and the perishable nature of the product. These countries compete for market share and aim to supply lucrative markets in the Northern Hemisphere. There is much competition in accessing northern markets because there is a higher demand for peaches and nectarines in the Northern Hemisphere due to the higher propensity to consume fresh fruit (Cirilli et al. 2016). During the Southern Hemisphere's harvest season, this region is unable to produce due to global seasonal shifts (Pieterse, 2013). Hence, this provides a ready market for Southern Hemisphere producers.

Figure 2.3 shows the market share of the six Southern Hemisphere exporters that participate in the international fresh peach and nectarine market. As shown, Chile has the dominating position as it accounted for 62.3% of the exports during the 2017/18 season. South Africa, which had a market share of 17.4%, was ranked in third place after Argentina which had a market share of 18.1%. Figure 2.3 shows that Argentina, New Zealand and Brazil are small players in this market as these countries' market shares do not exceed 2.5%. Due to the geographical location of the counties, South Africa competes with Chile in reaching its oldest and most lucrative markets in Europe and United Kingdom. Competition with Australia is mainly in the Far East and Asian market where Australia also has a distance advantage.

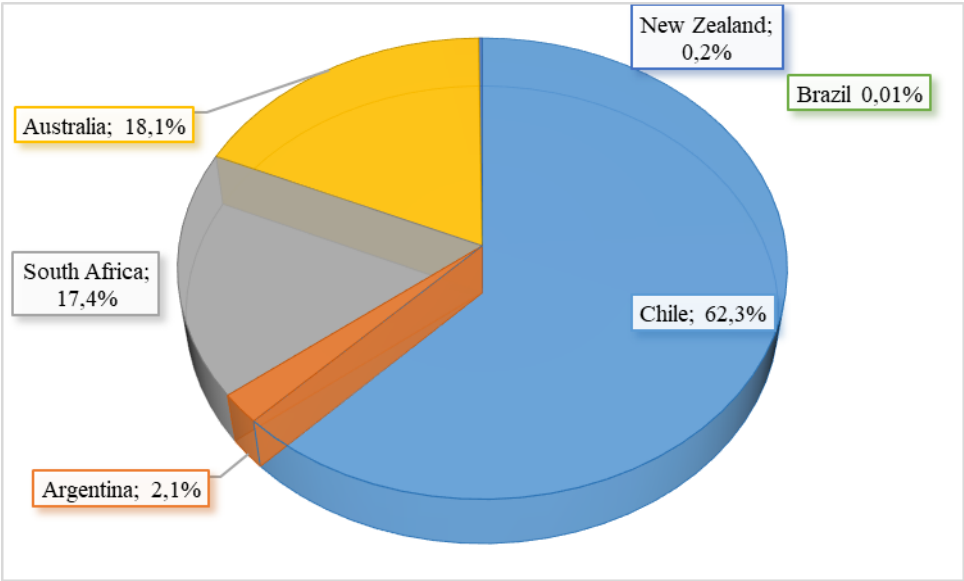

Figure 2.2: Market share of Southern Hemisphere exporters

Source: ITC, 2019.

As illustrated in Figures 2.2 and 2.3, South African fresh fruit supply to the export market is not evenly distributed in throughout this period. Exports are done using cultivars that harvested either early or late in the harvest season of the Southern Hemisphere. This is done in order to gain a competitive advantage over competing countries which experience that same peak production period but do not have suitable cultivars or capabilities to produce very early or very late in the season (DAFF, 2015). South Africa gains a substantial competitive advantage using this export strategy as it has managed to obtain premiums that range between 50 percent and 100 percent above Chilean cultivars (DFB, 1990; DFB, 1994). According to DFB (1994) as soon as the season peak arrives (especially in the second and third week of December), Chile supplies its fruit on the global markets during these peak period and this over-supply of the perishable product makes the market prices plummet to levels which are uneconomical for South Africa. South Africa often diverts its fruit to the alternative markets during this time.

As a result of the industry's export strategy, the industry exports have a bimodal distribution which peaks in week 47 (Mid-November) and week 6 (Mid-February) during the 26-week harvest season (DAFF, 2010). This export distribution is illustrated in Figure 2.2 which shows the distribution of the cartons of peaches that were exported during the 2017/18 export period. As shown in the graph, the industry exported almost 15 000 cartons during its first peak in November or December. The amount of fruit supplied to the export market significantly decreased between week 52 and week 8. The second peak in export volumes was experienced during week 10 where 6 900 cartons were delivered for export. The second peak was relatively lower, as shown. The difference in the quantity of fruit in each export period is determined by the cultivars available to the industry. There were a larger number of peach cultivars that

were harvested in the early-season period than the late-season period. The data in Figure 2.2 shows that there are more early ripening peach cultivars that are utilised for South African fresh exports as compared to the ripening cultivars.

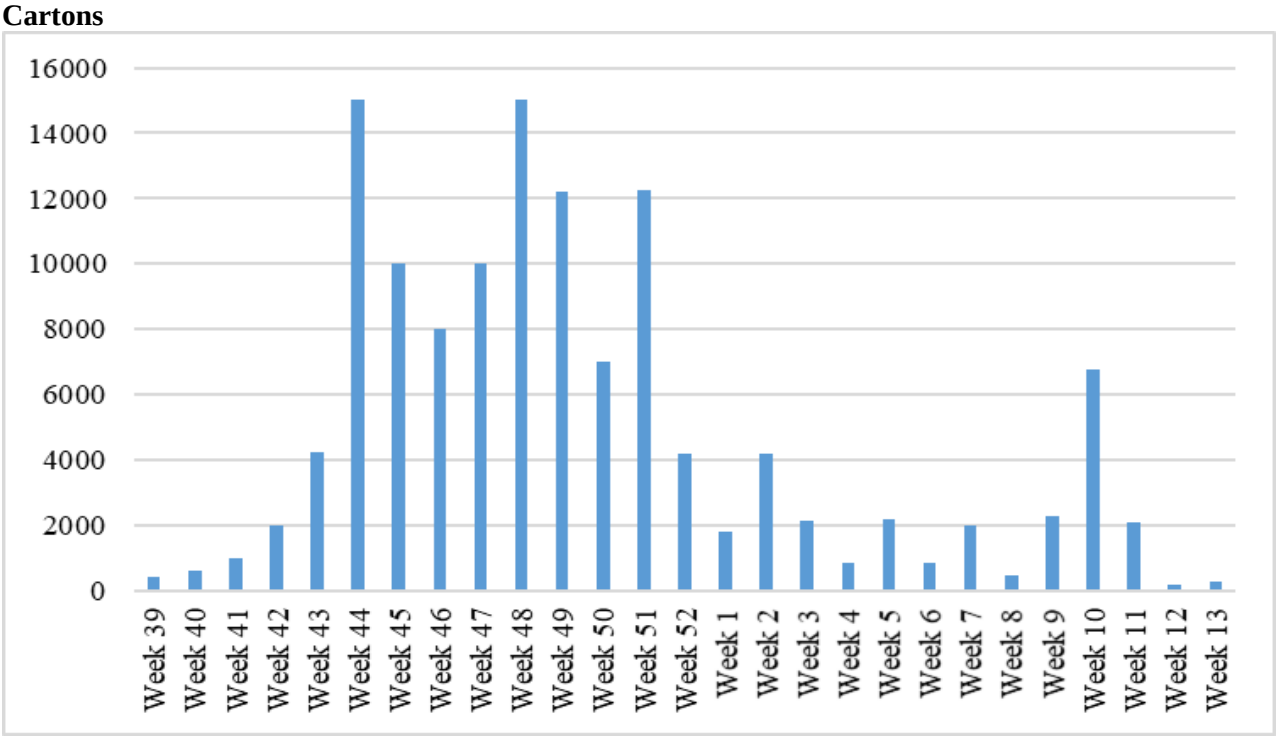

Figure 2.2: Number of peaches cartons passed for exports in 2018
Source: PPECB, 2018.
Note: One carton = 2.5Kg

The bimodal distribution of export-supply is more pronounced when viewing nectarine delivery statistics as shown in Figure 2.3. As shown in Figure 2.3, the nectarine exports peaked at 500 000 cartons (1 250 tons) and 320 000 cartons (800 tons) which were delivered during week 48 and week 7-8 respectively. A comparison of Figure 2.1 and Figure 2.2 shows that significantly larger quantities of nectarines are exported as compared to peaches. Given that the fresh export market in the premium market of the industry, the statistics show the strategic importance of nectarines in this market. This is view with the relatively small production area of these fruit types as discussed in section 2.2.

Cartons

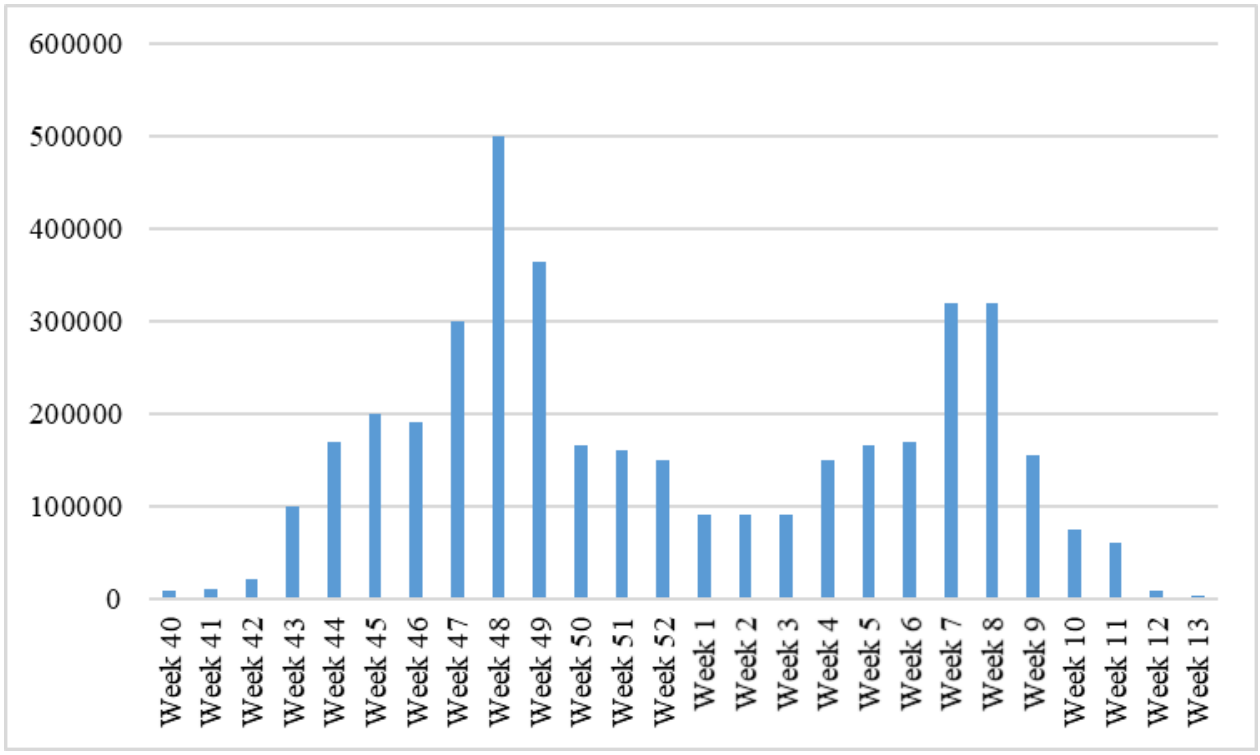

Figure 2.3: Number of nectarine cartons passed for exports in 2018
Source: PPECB, 2018.
Note: One carton = 2.5Kg

Table 2.4 shows the cultivars that were utilised during the 2017/18 export period. The table only shows cultivars which accounted for more than 1% of the annual export delivery. As shown, the cultivar called Temptation was the most demanded peach cultivar and it accounted for 12.4% of the fresh peach exports in 2017/18. A cultivar called Alpine was the most demanded nectarine cultivar and it accounted for 18.2% of the nectarine fresh exports in 2017/18. As shown in the table, there was a higher cultivar concentration in the top-2 nectarine cultivars as compared to the peach cultivar. However, when demand concentration per cultivar was compared at the level top-5 cultivars, the percentages were almost equal. These top-5 popular cultivars are responsible for creating the off-peaks volumes illustrated in Figures 2.2 and 2.3.

Table 2.4: Export per cultivar for peach nectarine cultivars

Peach exports			**Nectarine exports**		
Cultivar name	Percentage	Cumulative percentage	Cultivar name	Percentage	Cumulative percentage
Temptation	12.4	12.4	Alpine	18.1	18.2
Ambercrest	11.6	24	August red	14.5	32.7
Jim Dandy	7.1	31.1	Super star	4.9	37.6
Transvalia	7.1	38.2	Sunburst	2.9	40.5
Fairtime	4.7	42.9	September bright	2.9	43.4
Spring Princess	4.5	47.4	Summer Bright	2	45.4
Brittaney Lane	4.3	51.7	Summer Fire	1.6	47
Rich Lady	4	55.7	Fantasia	1.5	48.5
Scarlet Rich	3.9	59.6	Arctic Star	1.4	49.9
Majestic Delight	3.8	63.4	August Bright	1.4	51.3
Earliblush	3.2	66.6	Skye	1.4	52.7
Burpeach 13	2.9	69.5	N47-13(Luciana)	1.4	54.1
December Princess	1.7	71.2	Fire Pearl	1.3	55.4
PEO 04/26	1.5	72.7	Ruby Diamond	1.3	56.7
Alpine Delight	1.5	74.2	Regal Pearl	1.3	58
Excellence	1.4	75.6	Margaret's Pride	1.2	59.2
Summertime	1.3	76.9	Ruby Sweet	1.2	60.4
Nivadonna	1.3	78.2	Autumn Bright	1.2	61.6
Snowcrest	1.3	79.5	Crimson Glo	1.2	62.8
Sweet Dream	1.2	80.7	Summer Bright	1.1	63.9
Crimson delight	1.1	81.8	Giant Pearl	1.1	65
Juliepretty	1.1	82.9	Starborne	1	66
Snow Angel	1.1	84	Zee Glo	1	67
Juliepretty	1	85	Flavela (N2-36)	1	68
Snow Angel	1	86	Red Jewel	1	69
Julienice	1	87	Fire Sweet	1	70
Oribi	1	88	Diamond Zee	1	71
Princess Time	1	89	Snow Pearl	1	72
Ivory Duchess	1	90	Royal Ruby	1	73
Summer Zee	1	91	Unico	1	74
Sweet December	1	92	Other	26	100
Earlirisch	1	93			
Other	7	100%			
Total cartons	**2 159 179**		**Total cartons**	**4 216 785**	

2.7 Sustainable production and consumer demands of fresh peach and nectarine industry

As peaches and nectarines are not indigenous to South Africa, the issues of adaptability of the fruit trees and the production techniques to local production conditions have been central to the industry's growth and development (Pickstone, 1917). Market demand factors (particularly consumer demand of perfect quality fruit) have also been instrumental in shaping the growth path of the industry. The interaction of between these two factors has shaped the industry into three phases of growth and development.

In the first phase, the development of farming systems that promote sustainable production were pivotal to the industry's development. In these early years of the industry's establishment, environmental adaptation and product quality took centre-stage due to their importance in ensuring production feasibility and market access. However, the balance between the two areas of importance was not always easy to strike as it was common to find cases where the use of high-quality fruit varieties was often abandoned in exchange for lower quality cultivars which were easier and cheaper to grow regardless of the lower market price they attained (Pickstone, 1917). This problem persisted because most of the cultivars that were utilised during this phase of industry development were imported and unadapted to the local production conditions. This bottleneck slowed the industry's growth as peach production was used to earn sundry income in apple plantations and were uprooted as soon as the apple trees came into bearing (Black, 1947).

The second phase of the industry's growth was ushered in by the discovery of local landrace, cling peaches (Transvaal varieties) in the 1930s to 1950s. The genetic make-up of these varieties enabled them to be adapted to the local production area (Hurter, 1978). Most of these cultivars had yellow flesh colour and had long shelf-life hence they met the consumer expectations. Adapted cultivars enabled the geographical spread of production into areas with harsh environments and facilitated participation in premium markets due to the improvements in fruit quality (Pieterse, 2012). This ability to meet the two criteria for industry growth. More importantly, these cultivars were clingstone peaches and were well adapted to meet agro-processing requirements. The discovery and development of these cultivars allowed for the development and establishment of the canning industry that performed well with the aid of the numerous government export incentives. Their ability to meet consumer preference for sweet and brightly coloured fruit also contributed to the success of South Africa's canned fruit (Kaplan and Kaplinsky, 1999). As result, there has been a dominance of the canning market in the South African peach and nectarine industry.

The third phase of development resulted from changes in consumer preferences in the European Union markets. Since the 1970s there has been a gradual shift in preference from yellow-flesh cultivars to white-flesh cultivars, as well as a shift towards nectarines as opposed to peaches. Characteristics of nectarines such as less hair, higher aroma, more blush red or colour and higher sweetness resulted in an increase in their demand. The South African industry adapted to such shifts by using larger proportions of imported cultivars for its exports. Meeting the market's demand has been attributed to improvements in production technologies which have been enabled growth in fresh market volumes sent to export markets. For example, the use of dormancy breaking-agents allows the planting of unadapted cultivars in warm areas (Pieterse et al., 2006) and the use of modern trellising can allow the training of unadapted cultivars. Aided by innovations in the supply chain, the changes in technology have created conditions where the industry

to respond to price incentives offered by the international fresh fruit market which provides a price which was twice as high as local prices and seven times higher than prices offered by the processing market. Another factor that has also influenced this growth in demand for fresh fruit has been the higher demand for nutritious food (Byrne, 2002). The increase in consumer-orientation of agribusiness has led to compromises in sustainable production. However, consumer awareness of the importance of sustainable production has led to an increase in the demand medication from being solely motivated by hedonic values.

The industry has seen an increase in its gross value of production in this third phase. According to DAFF (2015), the industry doubled its gross value production between 2004/05 and 2013/14.This increase has occurred as the area planted to the industry has been decreasing. Other factors that have worked against the industry are: reductions in government production incentives (production subsidies), increase in competition and reductions in export subsidies (Mashabela and Vink, 2008). According to HORTGRO (2019), the industry has experienced an average decrease of 4% in its land area over the period 2016/17 and 2018/19. BFAP (2017) reports that the industry has been going through a period of consideration where it maximises the revenues on the least area produced. According to HORTGRO (2018), the biggest decreases have been in area planted to clingstone varieties which have experienced an average decrease of 6% in its land area over the period 2016/17 and 2018/19. This trend is likely to continue as the HORTGRO (2019) statistics show that the only 2% of the clingstone orchards have trees in the 0-2years age group while 13% of the nectarine orchards have orchards have trees in the 0-2 age range. These data indicate that the percentage of fruit deliveries to the fresh market is likely to increase in the future.

CHAPTER 3

Manuscript 1: An innovative market approach to analysing the fruit quality changes in South Africa's peach and nectarine cultivar market[2]

Abstract: *The global peach and nectarine industry has achieved significant milestones in producing good quality and high quantities of cultivars. The proliferation of cultivars beyond national boundaries has been facilitated by various policies such as intellectual property policy, trade policies and production policies. This paper analyses the quality trends of eight genetic attributes in the cultivars that were used in South Africa's fresh export market between 1956 and 2015. This is done in order to provide an inventory of the cultivar characteristics that have been proliferated by cultivar selection strategy. The investigation is aimed at revealing weather there is a co-existence or trade-off between cultivar characteristics that promote sustainable production and non-environmental characteristics in the cultivars used for South Africa's peach and nectarine industry's fresh fruit exports. Ranking "quality" in the cultivars' attributes was achieved by utilising a three-point Likert scale and this was done according to the characteristics' ability to meet the industry's changing production and consumer demands. Although, the results of the analysis show a general improvement in quality for both the production and organoleptic cultivar characteristics there was more of a trade-off between progress in reaching sustainability goals and with improving consumer satisfaction. The paper concludes that this result provides information that can be used to develop markets that can be created for the narrow market niche of cultivars that have the unique ability of providing the two valuable characteristics.*

Keywords: Market development, consumer value, consumer demand, sustainable production, international trade

3.1 Introduction

South Africa is one of the prominent Southern Hemisphere countries which supply fruit to the global peach and nectarine industry (Byrne, 2005). Although most of the country's produce is processed into canned products, the industry has seen an increase in the amount of fruit that is supplied to the fresh fruit market (DAFF, 2018). Supply to the international fresh fruit markets increased from about 400 tonnes (1.9 percent of total annual production) to over 10 000 tonnes (6 percent of total annual production) between 1949 and 2012. The increase in trade volumes has been accompanied by an increase in market diversification. Export markets have gradually shifted away from being concentrated in the United Kingdom and towards the southern and eastern parts of the world. In 2018, the majority of the fresh fruit produced was exported to the United Kingdom (50%), Netherlands (18%) and the United Arab Emirates (13%) (ITC, 2019).

The growth in international market participation has been attributed, in part, to an increase in the adoption of adapted and better-quality cultivars, improvements in cold chain management, trade liberalization and

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the strengthening of intellectual property rights. The increase in the availability of improved cultivars has been made possible through the breeding efforts of both local and international breeders. Much has been documented on the history of country's federal cultivar development programme, key breeding priorities, breeding methods, cultivar use patterns and cultivar concentration measures (Pieterse, Smith and Lotz, 2012; Pieterse, Cook and Theron, 2006; Pieterse, 2013). However, analysis of the trends in quality have not been documented. This gap in literature also persists amongst global studies that have provided an account of the funding patterns, selection and turnover of cultivars and other genetic material, adoption rates, shifts in the geographical distribution of modern varieties, the type of intellectual property rights utilised, and changes in the types of breeding techniques used (Byrne, 2005; Fideghelli et al., 1998). This paper strives to fill this gap in literature. It precisely aims to use this inventory to evaluate the degree of interdependence and/or trade-off between cultivar characteristics that promote the meeting of market demands versus characteristics that promote sustainable production. By so doing it answers the question, "What has been the implied environmental and social cost of providing a product that that meets the quality standards that consumers expect?"

According to Curzi, Raimondi and Olper (2015), these two forms of food quality have taken centre stage in 21st century agrifood markets. It is also essential to calculate and record such trends as they provide ways of communicating the contributions of Science to the agri-food industry's development. By so doing, such studies highlight the positive effects of research engagements on market development to laymen or non-agriculture professionals. Taking such an inventory enables robust analysis of the industry's present positioning and comparing this with a long time series provides insights on areas of improvement. This is important in such an industry where the cultivars take a long time to develop, the production seasons occur once and the biggest threats such as climate change are gradual and enduring.

Quality is a relative phenomenon, which is dependent on a myriad of cultural constructs (Byrne, 2005; Byrne, 2002). Thus, this characteristic allows for the application of a variety of approaches in its measurement. The current study considers eight cultivar characteristics that have been included as the most prominent quality indicators in the global market as stated by Bruhn (1994), Fideghelli et al. (1998), Byrne (2005), Huysamer, (2006), Cembalo, Cicia and Del Giudice (2009), Delgado, Crisosto, Heymann, and Crisosto, (2013), and Cirilli, Bassi and Ciacciulli (2016). The eight characteristics considered are "fruit size", "fruit shape", "skin colour", "flesh colour", "flesh texture", "growth habit", "harvest period" and "chill unit requirement". Some characteristics such as acidity, aroma, and soluble sugar content, which could have made a substantive contribution to the discussion, could not be included in the study due to data constraints. However, the study captures the quality attributes used most by consumers in making purchase decisions (Cirilli *et al*., 2016) and production characteristics that are growing in importance (Groot and Alisu, 2015).

The remainder of this paper is structured as follows: Section 3.2 provides a brief literature review of the industry and past studies. Section 3.3 gives an account of the type of data used in the study. Section 3.3 details the calibrations of the quality scale used in this study. Section 3.4 provides the results of the analysis and section 3.5 concludes the paper.

3.2 Literature review

There are a few studies that have analysed the global peach and nectarine industry's bio-technology market. To the author's knowledge, there are two studies that done this quite comprehensively. These global studies have given an account of the funding patterns, selection and turnover of cultivars and other genetic material, adoption rates shifts in the geographical distribution of modern varieties, the type of intellectual property rights utilised, and changes in the types of breeding techniques used (Bryne, 2005; Fideghelli, Della Strada, Graca and Morico 1998). Fideghelli et al., 1998 analysed the global industry for the period 1987 – 1996 and found that there were significant shifts in the industry that were characteristic of all producing countries. These changes included shifts in production from temperate climates to warmer tropical production areas and the use of cultivars and rootstock developed from controlled breeding as opposed to open pollinated cultivars. These study also reported that global trends also show an increase in high density planting, cross-breeding with almonds and plums, and high priority on cultivar breeding as compared to other pomological and post-harvest research activity. According to Fideghelli et al. (1998), other global changes included an increase in nectarine production as opposed to peach production, an increase in the breeding of white-fleshed cultivars as opposed to yellow-fleshed cultivars, and an increase in private sector breeding and funding as opposed to public sector dominance.

The review by Byrne (2002), which was more recently, confirmed the earlier trends and reported new trends. For example, the study reported that the majority of cultivars were bred in the USA (50%), France (18%) and Italy (12%). Lesser amounts are developed in South Africa, Australia, Asia (mainly China and Japan), and Latin America (mainly Mexico and Brazil). This is an interesting statistical finding given that the fruits originated from China. Byrne (2005) reported that there was a general increase in protected varieties and flat or doughnut shaped fruit. The study found that the concerns on environmental foot print of production has been pervasive greater concern of quality (intrinsic and extrinsic cultivar characteristics), and there was more diversify in niche classification (such as low acid fruit). There was an increase in the development and use of more simplified orchard practices mainly adapted to modern tree structure (dwarf and up-right growth habits), and modern breeding techniques such as the use of molecular markers.

More recent analyses on bio-technology trends on industry are available for the South African market. These have largely confirmed that the local industry were sync with global changes. Studies on South African peaches and nectarines have particularly documented on the history of the country's federal

cultivar development programme, changes in key breeding priorities, the evolution of breeding methods, cultivar use patterns and cultivar concentration measures (Pieterse, Smith and Lotz, 2012; Pieterse, Cook and Theron, 2006; Pieterse, 2013), however analysis of the trends in quality have not been documented. This contribution to literature also determined the type of characteristics that are currently proliferated and compares the dominance of characteristics that promote sustainable production to the characteristics which provide aesthetic value and promote consumers' eating quality. This is important information as this industry is demand-driven and it answers the question, "Is the pursuit of meeting consumers demand at the expense of our environment and the welfare of farmers?" The paper's findings contribute to the ethical debate about fair value and sustainable exports.

3.3 Data

The current study used cultivar descriptions that were collected from South Africa's Department of Agriculture, Forestry and Fisheries Plant Breeders Rights registries, which is a data-repository conforming to the format stipulated by the International Union for the Protection of New Varieties of Plants (UPOV). Other cultivar descriptions were sourced from the US Department of Agriculture–Agricultural Research Service's (USDA-ARS's) Registries for New Fruit and Nut Cultivars (List 35 – List 48). The Agricultural Research Council's (ARC's) technical bulletins also provided cultivar descriptions for old locally-bred cultivars. Cultivar descriptions for locally-bred cultivars were acquired from the ARC cultivar online repository. As trait rankings are susceptible to changes in environmental conditions (Mounzer et al., 2008; Sarkhosh et al., 2016); the cultivar descriptions from the prominent breeders of imported cultivars operating in the local market were also consulted to ensure UPOV and USDA-ARS ranking consistency. Only cultivars that contributed at least 1% of the annual fruit delivered for export and for at least three years between 1956 and 2015 were considered for the study. Thus, the data used captured 78 - 100% of annual delivery for annual fruit exports in the study period in focus. The data used to identify annual cultivar-use and the percentage contribution of each cultivar to annual exports was calculated from *Key Deciduous Statistics*; a journal published annually by the deciduous fruit growers association HORTGRO the period after 1993. The annual reports of the predecessor organisation, the Deciduous Fruit Board, were used for the years before 1994. These were sourced from a monthly journal called the *Deciduous Fruit Grower*.

3.4 The computation of quality indicators

The identified data sources contained 15 to 67 fruit-trait indicators that are used to describe the characteristics of cultivars. Only eight cultivar characteristics were considered as quality indicators in this study. These cultivar characteristics were "fruit size", "fruit shape", "skin colour", "flesh colour", "flesh

texture", "growth habit", "harvest period" and "chill unit requirement". A three-point Likert scale was used to rank these cultivar attributes. A score of 3 implied that the cultivar was rated as having an excellent trait, which enabled the cultivar to be aligned with existing and future market opportunities or production challenges in South Africa. A score of 2 implied that the cultivar was rated as having a good trait, which enabled the cultivar to be adapted to existing market opportunities or production challenges in South Africa. A score of 1 implied that the cultivar unsustainably met the production requirements, was acceptable for export use but the trait did not enable the cultivar to fare competitively with regards to addressing market and production demands of the prevailing age. Data availability, as well as interpretation feasibility, were used to determine the number of categories on the Likert scale. A three-point Likert scale was also used because it provides acceptable correlation coefficients in the analysis (Di Franco and Marradi, 2013). The current study follows an analogy provided by Groot and Albisu (2015), which ranked peach cultivar characteristics into three categories when investigating consumer preferences to the fruit's hedonic or organoleptic characteristics.

This method was used because of the variable form of the data (ordinal and scale) as well as the variable way the data provided in the different sources utilized. For example, some sources provided data of certain characteristics measured on a cardinal scale while other provided the data on an ordinal scale. Hence, it was possible to convert the former data type into the later while the reverse was impossible. A three-point scale was also used as it provided categories that were wide enough to guard against any overlap in the categories in the ordinal data. This was particular important for data source which gradually changed the number of categories in their ordinal scales between 1950 and 2018.

The section below explains the importance of each characteristic and details the calibrations of the 3-point Likert scale used to harmonize the two data recorded according to the UPOV and USDA-ARS guidelines. Refer to Government of India (undated), CPOV (2012) and Maloney (2006) for pictures and illustrations of characterised below.

3.4.1 Cultivar chilling requirement

Chilling requirement refers to the duration and degree of cold needed for a particular cultivar's flower to bloom and progressively produce fruit (Layne and Bassi, 2008). Cultivars are classified as having high, medium and low chilling requirements where high chilling requirement implies longer hours under cold temperatures (Pieterse *et al*., 2006). Climate experts predict that climate change is likely to increase temperatures in South Africa (WCG, 2014), hence, the highest quality category for this study is represented by cultivars with low chilling requirements as this would ensure good yield despite warming winters that will result from climate change.

Details of the calibration of the study's three-point Likert scale are shown in Table 3.1 below. As shown, A score of 3 is assigned to a cultivar that has low chilling requirement (requiring less than 400 hours), score of 2 is assigned to a cultivar that has medium chilling requirement (requiring between 400 and 799 hours) and a score of 1 is assigned to a cultivar that has high chilling requirement (requiring more than 800 hours). Demarcation of this classification was adopted from classifications discussed in Pieterse et al. (2006).

Table 3.1: Ranking cultivar chilling requirement

Ranked first **Score = 3**	**Ranked second** **Score = 2**	**Ranked first** **Score = 1**
Low Chilling requirement <400 Infruitec Chilling Units	Medium Chilling requirement 400 - 800 Infruitec Chilling Units	High Chilling requirement > 800 Infruitec Chilling Units

Source: Pieterse, Smith and Lots (2006).

3.4.2 Cultivar's growth habit

The data showed that the cultivars used in South Africa have upright, semi-upright/spreading or spreading tree structures. Of the three classifications, the upright tree structure was ranked highest quality as this growth characteristic has a higher ability to promote the development of sturdy branches and a fruiting habit that reduces the risk of wind damage (Pieterse *et al*., 2006). Additionally, this tree structure is more adapted to the modern high-density plantings, which enable higher returns to fixed investments. A spreading growth habit was ranked the lowest because of its limitations in providing this utility.

3.4.3 Fruit supply date

A cultivar's supply period is arguably the most critical criterion for cultivar selection and holds priority by all participants in the fresh export value chain. Consumers place a higher value on fruit that is availed outside the peak supply period as this implies an extension of their consumption period. This value is often reflected in the market prices that tend to be higher during the off-peak period when there is a relatively higher demand than supply. Hence, this study assigned a higher quality score to cultivars that were harvested furthest away from the country's peak harvest period. The South African harvest stretches between week 36 - week 14 (September and April) (HORTGRO, 2012). For ranking this characteristic, this harvest period was divided into four week periods. The week 48 – week 51 (mid-November and mid-December) period is the country's peak harvest period and this was assigned a score of 1. The next one and half 4-week periods occurring before (Week 44 - 49: Late October- Beginning November) and after (Week 52 - 5: Late December - Beginning February) this peak period were assigned a score of 2. The two 4-week periods in the country's harvest period occurring furthest away from the peak harvest period were assigned a score of 3. These periods fell between week 36 – week 43 period (Beginning September- Mid

October) and week 6 – week 13 period (Mid-February - Beginning April).The calculation of the three time-periods associated with fruit harvesting period is shown in Table 3.2 below.

Table 3.2: Ranking cultivar supply dates

Ranked first Score = 3	Ranked second Score = 2	Ranked first Score = 1
Classification using USDA-ARS metrics		
Very early (Week 36 - 43 : Beg Sept- Mid Oct) Vey late (Week 6 - 13 : Mid Feb - Beg April)	Early (Week 44 - 49: Late Oct- Beg Nov) Late (Week 52 - 5: Late Dec - Beg Feb)	Week 48 – 51 Mid Nov - Mid Dec
Classification UPOV metrics		
Very Early and Very Early to Early Very Late and Very Late to Early-Late	Early/Late and Medium-Early-Late	Medium

Source: Author's conceptualization from UPOV (2014) and USDA-ARS (various years)
Note: Beg = Beginning; Nov = November; Dec = December; Feb = February; Sept = September; Oct = October
Note: UPOV = International Union for the Protection of New Varieties of Plants
USDA-ARS = United States Department of Agriculture–Agricultural Research Service

3.4.4 Fruit shape

Most peaches have round shapes while others are ovate (egg-shaped) in cross-section, oblate (flattened globes) and flat, peevil or doughnut-shaped (Layne and Bassi, 2008). The novel, doughnut shape was ranked as one with the highest quality score as it has the highest demand on the market because it is more appealing to the consumer. According to Jaeger et al., (2017) and Cirilli *et al*., (2016), this demand trend is evident in the western markets because there is a generally increasing demand for this quality as it satisfies consumers' desires for variety and higher quality. However, in Asia, the demand persists because this fruit shape presents the traditionally preferred fruit and represents a new high-value fruit trend (Zu-Hua and Zhen-Xiang, 1992). For this study, the flat fruit shape was assigned the highest score. The relatively less desirable trait ellipse or ovate as this trait is associated with relatively higher post-harvest losses due to its susceptibility to bruising. This was assigned a score of 1. Table 3.3 details the ranking of this fruit characteristic.

Table 3.3: Ranking cultivar shape

Ranked first Score = 3	Ranked second Score = 2	Ranked first Score = 1
Classification using USDA-ARS metrics		
Flat / Oblate	Round / Globose	Oval /ovate/ovoid Ellipse
Classification UPOV metrics		
Broad/Medium Oblate and Flat	Circular and Circular-Oblate	Broad/Medium Elliptic and Circular-Ovate

Source: Author's conceptualization from UPOV (2014) and USDA-ARS (various years)

Note: UPOV = International Union for the Protection of New Varieties of Plants
USDA-ARS = United States Department of Agriculture–Agricultural Research Service

3.4.5 Flesh firmness

Cultivars with firm-flesh are more desirable to consumers as they have a longer shelf-life because they are less prone to internal breakdown (rotting) and bruising (Okie, 1998). Firmer fruits are also more desirable and deemed as having better quality because firm-flesh allows additional tree ripening, which gives greater size and better eating-quality (which results from the longer time invested in the development of favour and colour) (Layne and Bassi, 2008). This study used fruit classification into clingstone, semi-cling and freestone to calibrate quality scale for this attribute. According to Maloney (2006), clingstone cultivars often have very firm or firm flesh (13 – 15 lbf) while semi-cling/freestone has medium-firm flesh (10 – 13 lbf) (Maloney, 2006). The lowest-ranked category is characterised by soft flesh which mainly occurs in freestone cultivars (6 – 10 lbf).

3.4.6 Flesh colour

Sixty years ago, white-fleshed peaches dominated the global markets, until yellow-fleshed varieties were developed (bred) (Layne and Bassi, 2008). At present, most commercially sold fresh peaches and nectarines are yellow-fleshed. However, the demand has begun to drift back towards white-fleshed varieties (Pieterse *et al*., 2006). White-fleshed fruits are much esteemed in Europe and Asia (Maloney, 2006). Therefore, they tend to fetch premium prices. This could be because white-fleshed peaches often have a more aromatic flavour, adding to consumer eating pleasure (Layne and Bassi, 2008). Due to the higher demand associated with this characteristic, this study scored the white-flesh characteristic with a higher quality score. According to Zu-Hua and Zhen-Xiang (1992), a good cultivar can generally be described as one that has bright-yellow, golden-yellow or orange-yellow flesh. This flesh colour is also important because it shows less bruising (Layne and Bassi, 2008). Due to these considerations, this study assigned the second quality ranking to this flesh-colour trait. Table 3.4 below details the calibration used for the present study's Likert scale.

Table 3.4: Ranking cultivar flesh colour

Ranked first Score = 3	Ranked second Score = 2	Ranked first Score = 1
Classification using USDA-ARS metrics		
White/ Red	Orange / Deep Yellow	Yellow / Light / Pale yellow
Classification UPOV metrics		
Greenish white/White/Creamy white	UPOV: Orange / Deep Yellow	Yellow / Light Yellow

Source: Author's conceptualization from UPOV (2014) and USDA-ARS (various years)

Note: UPOV = International Union for the Protection of New Varieties of Plants

USDA-ARS = United States Department of Agriculture–Agricultural Research Service

3.4.7 Skin colour

In general, consumers tend to prefer fruit that has some blush of red colour because it is attractive and this often (but not always) shows the fruit's maturity (Maloney, 2006). According to Layne and Bassi (2008), the normal blush is expected to be between 50-75%. However, the commercial market has moved towards more and more red colour (Groot and Albuse, 2015). Pieterse *et al*. (2012) report that the local breeding selection primarily aims to produce full red-skinned fruit in the case of cultivars destined for fresh consumption as this characteristic fetches higher prices. From an international competitiveness perspective, South Africa fairs more competitively with full red colour cultivars as other Southern Hemisphere competitors tend to produce fruit with a brighter coloured fruit for blushed cultivars. In this research, quality scores were awarded with increasing red colour of the cultivar. Hence a score of 1 was given to yellow-skinned cultivars while fruits were red. Table 3.5 below shows how this quality characteristic was categorized into three classes.

Table 3.5: Ranking cultivar skin colour

Ranked first Score = 3	Ranked second Score = 2	Ranked first Score = 1
Classification using USDA-ARS metrics		
Full red / > 75% Blush	20 - 75% Blush / Mixed colour	No / minimal blush
Classification UPOV metrics		
Large/very large	Medium	Absent/very small and small

Source: Author's conceptualization from UPOV (2014) and USDA-ARS (various years)

Note: UPOV = International Union for the Protection of New Varieties of Plants

USDA-ARS = United States Department of Agriculture–Agricultural Research Service

3.4.8 Fruit size

Size is a key quality characteristic in the international markets because it is the most popularly used and readily-available characteristic used to determine quality. Consumers tend to associate small fruit sizes with inferior and poor value (Bruhn, 1994), hence this trait was assigned the lowest quality score in this study. Larger fruits are preferred because they are perceived as providing larger proportions of the peach than stone, good ripeness and higher sweetness (Groot and Albisu, 2015). However, the majority of the European markets prefer medium fruit sizes while the United Kingdom and other markets outside Europe demand large fruit (Maloney, 2006). As South Africa's largest markets prefer large fruit as compared to middle-sized fruit (Valverde, 2015), the large fruit size was highest scored on the Likert scale.

Table 3.6 below shows how this characteristic was categorized into three classes. Score of 3 was assigned to a cultivar that has a diameter that falls within the 68-81mm range. This cultivar is classified in the Group A and Group AA or in Count 15 or Count 18. Other sources classify this fruit in the category of large or very large fruit. Score of 2 was assigned to a cultivar that has a diameter that falls within the 62-68mm range. This cultivar is classified in the Group B. Other sources classify this fruit in the category of medium-sized fruit. Score of 1 was assigned to a cultivar that has a diameter that falls within the 52-61mm range. This cultivar is classified in the Group C and Group D or in Count 28 or Count 30. Other sources classify this fruit in the category of small or very small fruit. This study's index reflects the general preference of the whole market. This result could suggest the good quality of the older cultivars.

Table 3.6: Ranking cultivar fruit size

Ranked first **Score = 3**	**Ranked second** **Score = 2**	**Ranked first** **Score = 1**
Classification using USDA-ARS metrics		
Group A and Group AA Count 15 and 18	Group B	Group C and Group D Count 28 and 30
Classification UPOV metrics		
Large-Very Large Diameter 68-81mm	Medium Diameter 62-68mm	Small-Very Small Diameter 52-61mm

Source: Author's conceptualization from UPOV (2014) and USDA-ARS (various years)
Note: UPOV = International Union for the Protection of New Varieties of Plants
USDA-ARS = United States Department of Agriculture–Agricultural Research Service

3.5 Findings and discussion

Two hundred and forty-seven cultivars met the criteria for inclusion in this study. However, the study used 225 cultivars due to data availability limitations. The 225 cultivars made up between 78 and 100% of the fresh peach and nectarine exports from 1956 to 2015. The study scope's 60-year time-period

divided into three 20-year focus periods during analysis. This was done because literature (Savage, 1983; Park and Florkowski, 2003) reports that cultivar-use generally has a 20-year turnover period for peach and nectarine cultivars. After a two-decade period, cultivars tend to be phased out and replaced by superior cultivars. Due to the advanced pace of breeding, competition and fast-changing consumer tastes and values, this turn-over period has been argued to be reduced.

Table 3.7 shows that there has been a general increase in the number of cultivars used for export during the period under study. As shown, 14 cultivars were utilised for export during the 1956 - 1975 period and these increased to 217 in the 1996 – 2015 period. A decrease in concentration is a good indication in the cultivar market as it shows an increased ability to meet the market's diverse quality demands. However, it is concerning to note that the increase in cultivar numbers in the last two-decade period was as a result of the use of new cultivars as well as old ones. One would expect that new cultivars that meet the changing production demands would be introduced to meet the market need rather than recycle the existing ones.

Table 3.7 shows that the industry excelled in providing fruit that satisfied the flesh and skin colour preferences during the first two decades under analysis (1956 – 1975). These two quality attributes had average scores of 2.93 and 2.5 respectively and show the highest levels of quality average scores for the whole study. During the 1976 – 2005 period, the highest quality scores were calculated under the chilling requirement and skin colour quality measures. The period 2006 – 2015 had the highest average quality scores attributed to fruit size and flesh colour quality indicators. These attributes had average scores of 2.42 and 2.48 respectively.

Throughout the whole period under analysis, the most significant movement in the average scores (1.43) was calculated for the flesh colour category, starting with a high consumer value score of 2.93, which dropped to 1.5 in the second period. This change is attributed to consumer preference shift from white-flesh to yellow-flesh during the 1960s – 70s. An average of 1.5 acquired which shows a significant number proportion of fruit having yellow-flesh implies that the industry was well-positioned to acquiring premium prices due to the satisfaction of consumer preferences. Ever since, the consumer tastes have reverted to white flesh cultivars the industry has struggled to make this shift in supply. The lag in supply response is attributed to the long time that is required to breed suitable cultivars and is cushioned by the lag in or lack of shift in some consumer segments' tastes which allows South Africa to continue to find a demand for its product. The traits that showed the lowest improvements were; growth habit (0.04), fruit shape (0.05) and skin colour (0.02). The biggest improvements were in fruit size (0.56) and flesh firmness (0.55). Improvements were also calculated in the lowering of the chilling requirement (0.46) and improvements in the supply period (0.33).

Table 3.7: Quality scores on cultivars used for exports: 1956 - 2015

	Number of cultivars	Supply period	Chilling Requirement	Growth habit	Fruit size	Flesh colour	Fruit firmness	Fruit shape	Skin colour
1956-1975	14	1,5	1,64	2,14	1,86	**2,93**	1,93	1,93	**2,5**
1976-1995	38	1,75	**2,39**	2,17	2,14	1,5	2,11	1,86	**2,33**
1996-2015	217	1,83	2,10	2,11	**2,42**	1,66	2,48	1,98	**2,48**

Source: Author's calculations

Note: Average scores for the top two attributes per analytical-focus period are written in bold

3.6 Conclusion

The study aimed to provide an account of the improvement of fruit quality that is attributed to genetic improvement in the cultivars used in South Africa's fresh export market. This is done in order to provide an inventory of the cultivar characteristics that have been proliferated by cultivar selection strategy. The investigation is aimed at revealing weather there is a co-existence or trade-off between cultivar characteristics that promote sustainable production and non-environmental characteristics in the cultivars used for South Africa's peach and nectarine industry's fresh fruit exports. The findings highlight that the exports showed a positive change in seven out of eight quality indicators during the time consider in the study. The only indicator showing a negative trend was the flesh colour indicator and this was attributed to changing consumer tastes and preferences. Amongst the indicators that showed positive growth trends, the biggest quality improvements have been in the fruit size and flesh firmness. Moderate improvements were noted in chilling requirement and improvements in the supply period. The least improvements were found in growth habit, fruit shape, and skin colour. There was a slight trade-off between these two type cultivar characteristics, which particular resulted in low expressions of characteristics which promoted farmers' welfare. Although, the results of the analysis show a general improvement in quality for both the production and organoleptic cultivar characteristics there was more of a trade-off between progress in reaching sustainability goals and with improving consumer satisfaction.

The paper concludes that this result provides information that can be used to develop markets that can be created for the narrow market niche of cultivars that have the unique ability of providing the two valuable characteristics. This is very important as global consumption of peaches and nectarines is decreasing while South African industry trends are showing that its participation in the market is being secured through the provision of organoleptic qualities which are at the expense of sustainable production. The two sets of characteristics considered are equally important in the survival of the industry therefore market-led solutions should be found to ensure that there is a way of incentivising the production of cultivars that will minimise this trade-off. Such a solution is very important because a request for consumers to sacrifice their hedonic value for the sustainability will not yield a lasting solution. Hence, future studies should be undertaken on ways of calculating the combined provision of these two types of

product value so that the industry can develop ways of encourage sustainable production and consumption. A market solution that promotes responsible consumption will ensure commitment by industry role-players in the whole value chain.

CHAPTER 4

Manuscript 2: Investigating South Africa's Fresh Peach and Nectarine Value Proposition: Measuring Progress on Achieving Sustainable Consumption in Exports[3]

Abstract: *The Sustainable Development Goals (SDGs) have cast a spotlight on the importance of adaption to climate change. However, progress in achieving SDG 12 which calls for, "responsible consumption and production" has been stalled by the unavailability of indicators that adequately capture and motivate increased responsible consumption. To fill this gap, this article presents an alternative indicator that makes use of cultivar characteristics and interrogates South African fresh peach and nectarine exports as a focus area. Principal component analysis is used to extract and summarize the product value propositions identified in composite indices that were constructed by weighting the proportional use of cultivars in exports between 1956 and 2017. The indices developed from the analysis were found to measure the provisions for sustainable consumption, good-quality fruit and off-peak fruit supply. The results showed that progress in the provisions for sustainable consumption and this was mainly driven by improvements in cultivars' climate change adaptability. However, the last two decades have seen successive lower readings on this index. Improvements in fruit quality index were found to be attained at the expense of farm enterprise productivity. The study recommends that strategies be developed to encourage the use of cultivars that promote responsible consumption because, if left uninfluenced, market forces could incentivize unsustainable production.*

Keywords: SDGs; responsible consumption and production; sustainable indicators; climate change adaptation

4.1 Introduction

Climate change is regarded by many as a defining challenge of our times (Stern, 2016), and thus, it is not surprising that the 2030 Agenda for Sustainable Development has two Goals (SDG 12 and SDG 13), both concerned with the mitigation of, and adaption to, this environmental phenomenon. SDG 12, in particular, aims to, "ensure sustainable consumption and production patterns" and acknowledges the link between consumer behaviour and success of the long-term efforts in combating climate change (Moyer and Hedden, 2020). The integration of sustainable consumption and sustainable production in this SDG has been hailed as an improvement in global development goal setting, as previous development agendas have failed to fully integrate these two aspects (Le Blanc, 2015). Such a merger of ideologies allows the development of approaches that bring together technical environmental indicators with consumer values. It consequently asserts Dahl's (2012) description of sustainability as being, "an ethical challenge which requires a new set of values-based indicators that measure and motivate the implementation of ethical principles."

Past efforts to encourage sustainable consumption have been designed around the concept of positive and negative incentives and using them to direct consumer behaviour. Examples of these have included the introduction of environmental taxes and eco-labels. Consequently, a shift towards sustainable

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consumption has occurred as a response to environmental legislation and/or a response to heightened consumer demand for products and services that have a relatively lower environmental footprint (Esfahbodi, Zhang and Watson, 2016). While a number of indicators have been subsequently developed to operationalize the SDG 12 (Dahl, 2012), the available SDG 12 indicators are not sufficiently capable of measure behavioural changes and are thus inadequate to advocate for continued improvements (Moyer and Hedden, 2020). For example, the current indicators which use data such as percentage of anthropogenic wastewater that receives treatment, municipal solid waste (kg/year/capita) and non-recycled municipal solid waste (kg/person/year) as proxies for responsible consumption do not reflect consumers' decisions to make more sustainable consumption decisions. As a result, available indicators do not capture the consumers' contribution to the fight against climate change that has resulted from the incentives directed towards this cause. Therefore, the aspects of shared responsibility in driving responsible consumption are not captured. In this light, changes in the values of such indices are limited in their ability to motivate for increases in sustainable consumption as the underlying data is not directly linked to consumer behaviour but associated with the actions of public administrative authorities.

A plethora of data has been used to measure market trends of eco-labeled products as indicators of sustainable consumption. Despite their plurality, these account for a small proportion of the agricultural products that are produced annually. Thus, the environmental implications of the food choices made on the majority of food eaten remains unknown. The method presented in the current study allows for the accounting of such food using widely available cultivar or seed data and shifts from relying on eco-labels which are often pricey to develop. As cultivar descriptive data has been harmonized by global intellectual property management organizations such as the International Union for the Protection of New Varieties of Plants (UPOV), this measurement allows for the development of comparable indices across countries and contributes towards the harmonization of indicators and advance measurement and operationalization of the SDG 12.

The current study makes a methodological contribution to literature by using data from cultivars that have been used to satisfy consumers' quality demands, and it develops a measure from the interplay between these characteristics and climate change adaptation characteristics to determine an indicator for sustainable consumption. For the purposes of this paper, good fruit quality shall refer to fruit with desirable physical characteristics as perceived by the consumer at the point of purchase. The study considers the principal external quality indicators that motivate consumption and purchase behavior and takes a long-term view (1956–2017) in calculating the provisions for sustainable consumption. In order to provide an unbiased perspective of the sustainability gains and losses, this composite index's patterns are compared with the patterns of those indices that do not represent an eco-efficiency value proposition.

Filling the identified gap in the literature is opportune for the agriculture sector, as it has received the highest prominence among other sectors in achieving sustainable growth, with the emphasis on the adoption of sustainable farming technology. Thus, the study provides an example of how the widely available data could be utilized to provide insights into the concept of sustainable consumption. The research also fills a critical need for new indices for measuring SDG 12, which has been reported as having the largest number of indicators (10 out of 13) that are not measurable (tier III indicators) (Adams and Judd, 2018). The current gaps in index availability provide a biased picture in determining whether countries are on the right path for achieving SDG 12 (Gomez-Paredes and Malik, 2018), therefore, the provision for such an indicator enables more precise calculations. This is important in directing the South African industry to formulate more effective or actionable strategies that could improve its performance in this area. The results of this study will also serve as a motivator for increased breeding investment and guide focus areas on long-term cultivar development.

This article is organized as follows: Section 4.2 reviews literature and previous studies that have measured SDG 12. The research methodology is introduced in Section 4.3, and this is followed by Section 4.4 which outlines the study's analysis process and highlights the key research findings. Section 4.5 discusses the results in the context of the market developments and provides wider implications of the research findings. Conclusions are drawn in Section 3.6.

4.2 Review of Literature

There has been an increase in studies that benchmark and evaluate progress in the achievement of the 2030 Agenda's SDGs. A significant rise in the development of methods and indices for measuring sustainable development has been noted since their announcement in 2015 (Gomez-Paredes and Malik, 2019). The rising trend has been attributed to their usefulness as communication tools and as variables in analytical procedures. These summary indicators continue to find relevance because they limit the number of statistics presented and allow for quick comparisons of country and industry performance (Freudenberg, 2003).

Deficiencies in indicators for SDG 12 have seen limitations in the number of studies evaluating this Goal. These deficiencies prompted the 2018 high-level political forum review to include two indicators for migrant workers' rights, and jobs and labour rights in the list of indicators measuring this SDG that were detailed, and are shown in Table 4.1 below (Adams and Judd, 2018). It has been noted with concern that 10 out 13 indicators listed in Table 4.1 are classified as Tier III indicator, lacking in suitable metrics for operationalization (Adams and Judd, 2018). The slow development of indicators for this SDG is slowing global development as research has shown that there is a relationship between successful measurement

and the progress in achievement of development goals (Schmidt-Traub, Kroll, Teksoz, Durand-Delacre and Sachs, 2017).

Table 4.1: Indicators of Sustainable Development Goal 12.

Target	Description
12.1	Implement the 10-Year Framework of Programs on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.
12.2	By 2030, achieve the sustainable management and efficient use of natural resources.
12.3	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.
12.4	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.
12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.
12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.
12.7	Promote public procurement practices that are sustainable, in accordance with national policies and priorities.
12.8	By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.
12.a	Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.
12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products.
12.c	Rationalize inefficient fossil fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

Source: United Nations (2015).

Efforts to explore different ways of improving national ratings on SDG achievement have drawn a demand for indices constructed from disaggregated data because these have been found to easily translate into action plans (Adams and Judd, 2018). Hence, several studies have been conducted to measure SDG 12 using specific municipal, market and/or industry-level data. For example, Adams and Judd (2018) carried out a study that measured SDG 12 using three indicators: “percentage of anthropogenic

wastewater that receives treatment", "municipal solid waste (kg/year/capita)" and "non-recycled municipal solid waste (kg/person/year)". These, as well as an index constructed by Le Blanc (2015), measured progress on achieving Target 12.4. Gomez-Paredes and Malik (2018) proxied progress using the measure of the increase in the hazardous waste generation (Indicator 12.2), while Campbell *et al*. (2018) report that other researchers have constructed a food loss index while measuring Target 12.3. According to Schmidt-Traub *et al*. (2017), most studies have utilized administrative data and trade statistics on waste generation to track progress using Indicator 12.5. However, the limitation with the indicators stated above is that they are not sufficiently sensitive to quantify changes in behaviour which results from an increased response to legislative directives and industry incentives that encourage collective societal efforts geared towards combating the negative effects of climate change (Moyer and Hedden, 2020). They characteristically measure the successes of the administrative and/or public office efforts to increase responsible consumption and do not filter down to measure individual consumer's behavior. Therefore, they are thus inadequate advocates of continued improvements in consumers' lifestyles as they do not reflect society's response resulting from an individual's behavioural decision. The approach taken in this study fills this gap as it provides a new set of values-based indicators that is reflective on consumers' purchase behavior.

In addition to benchmarking studies that have increased in popularity in literature, there has been a drive towards analyzing the linkages between SDGs. It has been envisaged that such links among Goals should facilitate the mainstreaming of dimensions that previously suffered from not having strong sectoral anchoring in development institutions (Dahl, 2012). According to Huan, Li and Lian (2019), sustainable consumption and production is an example of such an area that has largely benefited from the approach as it has often been addressed as an 'add-on' and not taking the centre stage. This study develops an indicator that assists in drawing a focus on this SDG and address this limitation.

Researchers have also found value in calculating SDG 12 by using product characteristics and market indicators. For example, data on the market share of goods with certified sustainability labeling have, in the past, sufficiently measured the progress on Target 12.1 (Huck, 2019). Such an approach has been taken as it has been acknowledged that achieving sustainability is fundamentally an ethical challenge and necessitates the generation of a new set of values-based indicators (Dahl, 2012). This is viewed as a more reliable approach for tackling the measurement problem, as it is recommend that indices use indicators that adequately represent the priorities and values of the underlying system that they measure. While this study takes a similar approach, it extends the literature by measuring implied sustainability, as the environmentally friendly attributes of the product are not disseminated to consumers.

4.3 Methodology

4.3.1 Data

This study used cultivar descriptions collected from Plant Breeders Rights registries of South Africa's Department of Agriculture, Forestry and Fisheries (DALRRD, 2019). These constitute a repository of plant intellectual property data conforming to a format stipulated by the International Union for the Protection of New Varieties of Plants. Other data cultivar descriptions were sourced from the US Department of Agriculture-Agricultural Research Service's Registries for New Fruit and Nut Cultivars (List 35–List 47). Cultivar descriptions for older (bred between 1936 and 1967) locally-bred varieties were acquired from the ARC-Culdevco cultivar repository (ARC, undated). Only those cultivars that made a significant contribution to annual fresh exports (greater than 1% of annual deliveries) between 1956 and 2017 were included in the study's analysis. The list for cultivars and percentage contribution to annual exports was calculated from *Key Deciduous Statistics*, a journal published annually by the deciduous fruit growers' association, HORTGRO, for the period after 1993 (HORTGRO, various years). The annual reports of the predecessor organization, the Deciduous Fruit Board, were used for the years before 1994 (DFB, various years). These were sourced from a monthly journal called The *Deciduous Fruit Grower*.

The cultivar-description data sources mentioned above contained 15 to 67 cultivar characteristic indicators. The sources measured each characteristic using 2-point to 15-point Likert scales. The characteristics used for this study were selected based on availability of data for the cultivars utilized for South Africa's exports. The eight cultivar characteristics that were selected for this study were: "chilling unit requirement", "growth habit", "harvesting period", "fruit firmness", "fruit shape", "fruit size", "skin color" and "flesh color". The study used two cultivar characteristics, "cultivar chilling unit requirement" and "cultivar growth habit", to indicate climate change adaptation. While it would have been interesting to include indicators for cultivars' varying water utilization, yield, and disease resistance levels, the available data for peaches and nectarines does not provide proxies that measured these characteristics. The remaining five characteristics were selected using the same criteria as stated above and served as indicators of consumer quality demands. Similarly, data covering the scope of this study that indicates information internal characteristics which significantly influence consumer behavior such as fruit sugar content and acidity were also unavailable.

4.3.2 Indicator Measurement

Similar to a study that was conducted by the Sustainable Development Solutions Network (2013), this study computed the indicators using a worst-to-best ranking method to develop a scale that measures the consumption and sustainability value for the cultivar characteristics. Using a 3-point Likert scale, coded 1

to 3, a cultivar's traits were ranked from least to most desirable. A score of 3 implied that the cultivar was rated as having an excellent trait, which enabled the cultivar to be aligned with existing and future market demands or production challenges in South Africa. A score of 2 implied that the cultivar was rated as having a good trait, which enabled the cultivar to be adapted to existing market demands or production challenges in South Africa. A score of 1 implied that the cultivar met the production requirements, albeit unsustainably and was acceptable for export use but the trait did not enable the cultivar to fare competitively with regard to addressing market and production demands of the prevailing age.

The ranking of the cultivar characteristics is shown in Table 4.2 below. A short description of the trait associated with each rank is also provided. For the two cultivar characteristics that indicate climate change adaptation, a high score or ranking implies a relatively higher ability to reduce the negative impact of climate change on production output and continued farming enterprise feasibility. That is, a cultivar with a low chilling requirement is better adapted to the changing climate as it would ensure consistently high yields (without the aid of production chemicals), regardless of the warmer winters that are induced by climate change. On the other hand, a cultivar with an upright growth habit is better adapted to modern, high-density planting which gives higher returns to production. This trait enables the recouping of money spent on the on-farm climate change adaptation investment. Similar to the former characteristics, the fruit quality characteristics (cultivar harvesting dates, fruit size, flesh color, skin color and flesh firmness) were also assigned ranking criteria that were literature-informed, but ranking additionally included information acquired from industry experts regarding the fruit quality preferences of South Africa's primary export markets (the UK, the Netherlands, the UAE, Saudi Arabia, Hong Kong-China, France, and Germany).

Table 4.2: Cultivar trait ranking criteria

		Ranked first (Score = 3)	Ranked second (Score = 2)	Ranked third (Score = 1)
1	Chilling unit requirement	Low Chilling requirement <400 Infruitec Chilling Units	Medium Chilling requirement 400 - 800 Chilling Units	High Chilling requirement > 800 Infruitec Chilling Units
2	Cultivar growth habit	Upright	Semi-upright/Spreading	Spreading
3	Cultivar harvesting dates	Very Early and Very Early to Early Very Late and Very Late to Early-Late	Early/Late and Medium-Early-Late	Medium
4	Fruit shape	Broad/Medium Oblate and Flat	Circular and Circular-Oblate	Circular and Circular-Oblate
5	Flesh firmness	Clingstone varieties 13–15 lbf	Semi-cling/freestone 10–13 lbf	Freestone varieties 6–10 lbf
6	Flesh colour	White/Red	Orange/Deep Yellow	Yellow/Light/Pale yellow
7	Skin colour	Full red/>75% Blush	20%–75% Blush/Mixed colour	No/minimal blush
8	Fruit size	Large-Very Large Diameter 68–81mm	Medium Diameter 62–68mm	Small-Very Small Diameter 52–61mm

Source: Authors' conceptualization.

*Note: lbf means pound of force

4.3.3 Analytical Methods

The Principal Component Analysis (PCA) approach was used to reduce the number of indicators to comprehensive product value indices or Principal Components (PCs). PCA is a suitable method for this analysis because it is an unbiased method ensuring that the attribution of each indicator in the composite index is based on the statistical behaviour of the underlying data, and not by preconceived notions of their influence (Moyer and Hedden, 2020). This approach has been used by other studies, such as Crisosto, Crisosto and Echeverria, 2006; Cembalo, Cicia and Del Guidice, 2009; Kappel, Fisher-Fleming and Hogue, 1996 that investigated the relationships between cultivar characteristics. Previous studies, such as Dahl, 2012; Huan, Li and Lian, 2019; SDSN, 2013 and Nhemachena *et al*., 2018, have used this explicit weighting technique in constructing composite indices measuring the progress in SDGs.

PCA is described as a dimension-reduction analytical tool that is used to reduce a large set of variables to a small set that retains most of the information from the large set. It uses a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables (Di Franco and Marradi, 2013). The analysis detects the structure in the relationships between underlying latent variables and performs an orthogonal procedure which transforms them into linear combinations of uncorrelated variables (called Principal Components). As illustrated in Equation 4.3 below, PCs *1* to *m* was generated from a set of variables X_1 through to X_n and weights a_{mn} was assigned to the *mth* principal component (*PCm*) and the *nth* variable.

$$PC_1 = a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n \quad (4.1)$$

$$PC_2 = a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n \quad (4.2)$$

$$\vdots$$

$$PC_m = a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n \quad (4.3)$$

The first PC accounts for much of the variability in the data, and each succeeding component accounts for as much of the remaining variability as possible. The weights for each PC are given by the eigenvectors of the correlation matrix or co-variance matrix. The variance for each PC is given by the eigenvalue of the corresponding eigenvector, and the sum of the eigenvalues equals the number of variables in the initial data set (Vyasand Kumaranayake, 2006). The proportion of the total variation in the original data set accounted by each principal component is given by dividing the PC's eigenvalue with the number of original variables extracted to generate it. The eigenvalues/weights of indicators within a component are used to interpret the meaning of each component (Howe *et al*., 2012). Hence, in this study, the product value proposition represented in each PC is interpreted as a reflection of the combination of the underlying indicators that contributed to its construction. This implies that a PC represents sustainable

consumption when both fruit quality and climate change adaptation indicators contribute to its construction and the PC represents quality when the latter remains uncaptured.

In extracting the indices, the Kaiser criterion of retaining PCs with eigenvalues greater than 1 was applied. Due to restrictions in data variation in the underlying data, a loading score threshold of 0.3 was used and polychoric correlations were used in the determination of the PC as the underlying variables. The acquired factors were rotated using varimax rotation method. Cultivar value scores were computed for each generated PC using regression analysis. These scores were generated in order to assign asset values to each cultivar for each of the derived PCs. The individual asset value scores were weighted on the proportion of a particular cultivar's contribution to the annual export regimen between 1956 and 2017, and aggregated to form the annual aggregated score. Normalization of the generated scores was done by calculating an average score for each value proposition's time series and dividing it into the annual aggregated score. The normalization exercise was done in order to enable comparability between indices. Hence, the resultant score for the composite index is the degree of deviation of annual performance from the indicator's mean. According to Saisana and Tarantola (2002), this aggregation method is the most suitable method for constructing the composite indicators that have a time series nature.

4.4 Results and Discussion

4.4.1 Descriptive Statistics

A total of 225 cultivars were used in this study. These made up 78%–100% of South Africa's annual export deliveries for the period between 1956 and 2017. Table 4.3 shows the average mean scores for cultivars used during this period divided into three 20-year periods. The study describes cultivar-use over a 20-year turnover period because Savage (1983) and Park and Florkowski (2003) report that peach and nectarine cultivars are generally phased out and replaced by superior varieties over a two-decade period. Due to the advanced pace of breeding, competition and fast-changing consumer tastes and values, this turn-over period has been argued to have been reduced to approximately 15 years.

Table 4.3 shows the trend for the average scores for the indicators of climate change adaptation have not shown a pattern of increasing values. As depicted in the table, the industry showed that environmental adaptability was at its highest during the 1976–1995 period. The indicator average scores were recorded at 2.39 and 2.17 for "chilling unit requirement" and "growth habit", respectively. The sector average scores fell to 2.10 and 2.11 respectively, during the 1996–2015 period, showing that the majority of the cultivars were less adapted to the negative effects of climate change. These results could be reflective of an increase in use of production innovations. For example the use of dormancy breaking-agents allows

the planting of unadapted cultivars in warm areas and the use of modern trellising can allow the training of unadapted cultivars. However, this is has high cost implications.

The indicators for fruit quality, on the other hand, showed a general increase in average scores during the 1957-2017 period. The biggest improvements noted were in the "fruit size" and "flesh firmness" indicators, which recorded average score increases of 0.56 and 0.55, respectively. The trend for "flesh color" average scores was different from other quality characteristics, as these showed a decreasing pattern. These results can be explained by the industry's efforts to meet the demands of shifting consumer tastes. At the beginning of the time series, the industry was well-positioned to meet the dominant preference for white-fleshed varieties present in its markets. This is shown by the high average score of 2.93. When the preference shifted toward orange or yellow-fleshed varieties (Layne and Bassi, 2008), the industry succeeded in matching the demand for orange or yellow-fleshed varieties during the 1976–1995 period as shown by the 1.5 average score. The data has shown that the industry has been sluggish in following the consumers' return to a white-flesh variety preference. This is partly because there has been an increase in diversity in South Africa markets that was especially noted after the deregulation of the industry in 1997 (Antony and Rao, 2007). In the 1950s, 97% of the South African industry exports were delivered to the United Kingdom, and in 2017, that country's market share had been halved and product preferences of markets in the Eastern Hemisphere had a higher influence on export product characteristics. In addition, the long turnover period of the cultivar development process, the trade-off nature of the quality characteristics, and the elevated production and market demands all make it difficult to quickly obtain cultivars that outperform and thus replace the existing cultivars.

Table 4.3: Average quality scores on cultivars used for exports: 1956–2015

	Number of cultivars	Chilling Requirement	Growth habit	Supply period	Fruit size	Flesh colour	Fruit firmness	Fruit shape	Skin colour
1956–1975	14	1.64	2.14	1.5	1.86	2.93	1.93	1.93	2.5
1976–1995	38	2.39	2.17	1.75	2.14	1.5	2.11	1.86	2.33
1996–2015	217	2.10	2.11	1.83	2.42	1.66	2.48	1.98	2.5

*Note: Highlighted values show the highest average scores attained for each sub-indicator in the time period under study.

4.4.2 Empirical Results

Table 4.4 shows that the study was able to extract three indices that summatively characterized the principal value proposition offered by South African peach and nectarine exports. These indices captured 47.23% of the variation in the underlying variables. This percentage give an indication of the size of the market segment that is explained by the PC results. The loadings for the dominant indicators (>0.3) for the product value propositions are emphasized in Table 4.4 in **bold** print.

Table 4.4: The Principal Component extraction

Component Matrix			
	PC1 Fruit quality	PC2 Sustainable consumption	PC3 Off-peak supply
Skin color	**0.707**	−0.195	−0.129
Flesh firmness	**0.579**	**0.394**	**0.488**
Growth habit	**−0.551**	0.106	0.212
Fruit size	0.357	0.114	0.128
Flesh color	0.139	−0.758	−0.082
Chilling unit requirement	0.090	**0.676**	−0.137
Fruit supply period	−0.144	0.085	**0.659**
Fruit shape	0.066	−0.288	**0.643**
Summary indicators			
Eigenvalues	1.361	1.273	1.143
Proportion of variance explained	17.017	15.932	13.655
Cumulative proportion of variance explained	17.017	32.949	47.235

Source: Author's calculations, 2019.

As shown, the first Principal Component (PC1) captured the highest number of cultivar characteristic indicators. This PC accounted for 17.017% of the total variation in the original indicators. The dominant cultivar characteristics for PC1 were "skin colour", "flesh firmness", "growth habit" and "fruit size". These characteristics had factor loadings of 0.707, 0.579, −0.551 and 0.357, respectively. Therefore, this PC represented a fruit quality index as the dominant characteristics which described fruit that is large, firm and red-skinned. The attained results concur with numerous past studies that have shown that perceivable quality attributes are consistently uncompromised features for exported fresh peaches and nectarines. In addition, the results show that there is a huge trade-off between these quality indicators and "growth habit". This finding indicates that the provision of good quality fruit, as described by the PC1's loadings, has been sustained through the sacrificing of farm productivity maximization. This result is concerning as it shows that there have generally been low prospects for the achievement of shared value where an increase in South African farmers' welfare is pursued in tandem with fruit quality improvement.

The cultivar characteristics captured in PC2 measure sustainable consumption, as it has statistically significant and positive factor loadings for "cultivar chilling requirement" and "flesh firmness" characteristics which represent climate change adaptation indicators and fruit quality, respectively. These factor loading which have value greater than 0.3 indicate the statically significance of characteristics. The negative and high factor loadings observed for the "flesh color" indicator shows that the sustainable consumption product value proposition is associated with orange or yellow-flesh varieties. This means that the orange or yellow-flesh firm varieties used for exports generally tended to be more adapted to the

warmer winters. Table 4.4 shows that PC2 accounted for 15.932% of the total variation in the original indicators.

The results show that PC3 measures a product value proposition that is crafted around the off-peak supply of large and firm fruit. This is evidenced by the three characteristics: “harvest period”, “fruit shape” and “flesh firmness” with loadings of 0.659, 0.643 and 0.659, respectively. This factor accounted for 13.655% of the variation in the data and was interpreted as one that measured the provision of off-peak fruit supply as a value proposition.

4.4.3 Reliability Test

Three robustness tests were performed. These were the Bartlett’s, Kaiser-Meyer-Olkin, and determinant’s tests. A value of 0.773 was acquired from the PCA’s determinant, showing that the analysis managed to capture a significant amount of the variation occurring between the different values in the cultivar characteristics observed. A p-value of 0.001 was acquired for the Bartlett’s test. This result shows that there was a significant level of correlation in the matrix of assets value indicators considered to justify the use of a data reduction procedure using PCA (Antony and Rao, 2007). A p-value of the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.5. According to Antony and Rao (2007), a value of no less than 0.5 indicates that patterns of correlations present in data are compact and that factor analysis yields reliable factors.

4.4.4 Composite Indices

As shown in Figure 2.3, the sector made the most progress in providing for sustainable consumption, which recorded a 3.05 score improvement on the composite index scale between 1956 and 2017 (an improvement from −2.78 to 0.28). The second-highest improvement of 2.13 points was calculated on the progress in delivering fruit quality, as there was an improvement from −2.11 to 0.02. Improvement on delivering fruit outside the market’s peak period showed a 1.39 increase, from -0.78 to 0.61.

Graphs for all three indices begin with readings below zero. This shows the relative difference in quality that was provided at time as compared to the baseline time of reference. The 1967–1988 period had the most fluctuations in index readings, as this period was characterized with significantly higher concentration of supplies towards peak season, and significant improvements in fruit quality and sustainable consumption. Of the three composite indices, the trend for sustainable consumption was the only index to break through the “zero-mark” and started recording positive numbers in 1987/88. The graph for fruit supply subsequently followed in 1999/2000, and lastly, the index for fruit quality in 2010/11. This means that the significant improvement in sustainable consumption can be attributed to improvements in the environmental adaptability of the cultivars used for exports, as the other indices

measuring fruit quality indicators showed a pattern different from that of sustainable consumption. Figure 4.1 also shows that the industry has failed to maintain the increasing progress in sustainable consumption provision, as the corresponding index shows a decreasing trend since the mid-2000s. The index for off-peak fruit supply was the one of the three indices that maintained a positive growth trend after 2000. As shown, the growth path of fruit quality improvement was broken in 2011/12 as the index reverted to a score of zero by the end of the time series.

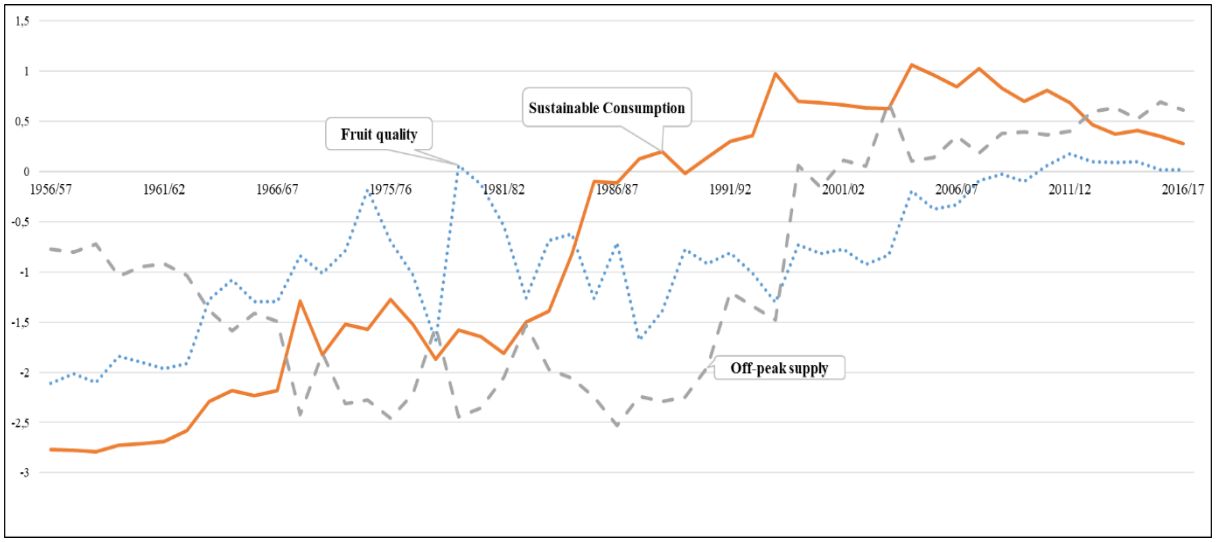

Figure 4.1. Calculated index for South African peach and nectarine exports: 1956/47–2016/17
Source: Author's calculations, 2019.

4.5 Discussion

The derived indices depict the market strategies that have been used to build and maintain the competitiveness of South Africa's fresh peach and nectarine exports. The index for fruit supply shows the long-term strategy that the industry has adopted. This strategy involves the use of as many cultivars as possible to supply the market before and after the Southern Hemisphere supply's peak period. The establishment of off-peak markets has been gainful to the industry as these markets have enabled the sector to attain price premiums of between 50% and 100% (DFB, 1994). The proportion of cultivars providing this value have significantly increased over time. This is shown on the index by scores which improved from negative numbers to positive figures. Reports have indicated that climate change has caused the fruit deliveries from other Southern Hemisphere countries to drift into this off-peak niche market and this is slowly eroding premiums of South Africa's fruit. Such shifts have increased competition in this market segment and have further driven improvements in South Africa's cultivar selections to ensure the safeguarding of this niche market.

The use of well-adapted cultivars has been one of the most important drivers of growth in the industry. The provision of cultivars that were adapted to a production environment led to significant growth in the nectarine subsector. As indicated by the PCA results, this market segment is mainly served by orange or yellow-fleshed, cling/semi-cling cultivars, and this finding may point to a new way in which this fruit variety could be marketed, as a significant proportion of the global market's consumers are turning away from this fruit variety type.

The provision of fruit of good quality has always been the prime prerequisite for participation in the exporting industry. This study corroborates this fact with its descriptive analysis findings which showed high indicator average scores at the beginning of the time series. Such a result indicates that cultivar selections have consistently been made with the aim of improving fruit quality throughout the whole period of focus for this study. However, the level of industry quality improvements that can be measured by a composite index is limited by the low probability of natural concurrent occurrence of excellent quality traits in cultivars. The magnitude of progress that can be measured on this index is largely limited by the strong trade-off that exists between quality traits and the high returns to farm productivity. Due to this disparate relationship, the index shows low figures and small positive values. This enduring trend means that the industry has had to sacrifice this dimension of sustainability in order to maintain its market presence and participation. This is a concerning result, as SDG12 advocates for responsible consumption as a strategy that ensures sustainable, long-term growth.

4.6 Conclusion

This study was carried out in order to provide an alternative way to measure trends in sustainable consumption and production. The constructed composite index used cultivar characteristics that indicated the environmental footprint and fruit quality attributes. In order to provide an unbiased perspective of the sustainability gains and losses, this composite index's patterns are compared with the patterns of those indices that do not represent an eco-efficiency value proposition. These indices measured fruit quality and the delivery of off-peak fruit supply. Of the three indices constructed, the index measuring responsible consumption showed the highest growth in values showing that the industry was making progress in balancing consumer quality demands and sustainable production as compared to progress in providing fruit of good quality or supply of off-peak fruit. This index had its highest values in the 1990s to the early 2000s, but deviated from positive growth in sustainability path in the mid-2000s. The study's results show that progress in the provisions for sustainable consumption was mainly driven by improvements in cultivars' climate change adaptability. The index for fruit quality showed increasing trend; however, improvements in this index had negative implications on productivity of farming enterprises. Growth was more consistent on the index measuring off-peak supply.

Different from previous indicators that were indicative of consumer behaviour, this study has provided an indicator that can link responsible consumption to purchase behaviour. To be more specific, the study has shown that preference for firm-fleshed and orange or yellow or orange-fleshed cultivars is associated with sustainable production, therefore, this provides a starting point on which type of fruit varieties can be promoted in order to advance the goal of improving responsible consumption. For example, marketing campaigns or positive incentives promoting the production or purchase of cultivars identified as meeting responsible consumption criteria can be developed. Further, the indices can also be used to influence the pricing of cultivars. That is, cultivars' ability to meet differing levels of these criteria should be reflected in the royalties. The increase in the production, adoption and consumption of these varieties can amount to an increase in responsible consumption. This is an improvement from past indices which measured improvements in public administrative systems. As shown by the study's findings, such efforts will increasingly be required going into the future as market forces (demand and supply) are likely to have negative implications for the environment if left unchecked.

CHAPTER 5

Manuscript 3: The influence of product quality on export performance[4]

This study evaluates the role of quality in influencing international trade. It argues that different types of product attributes confer different types of value and can explain the export performance. This investigation is done using the gravity model in which export earnings are regressed against indices for product value propositions, tariffs, and demographic, demand and economic indicators. It used panel data from South Africa's fresh peach and nectarine exports and 21 trading partners for the period 2001 and 2017. The study's results show that the delivery of products with off-season and aesthetic quality led to an increase in trade albeit not statically significant. On the other hand, improvements in eco-efficiency in products (sustainable production and consumption provisions) were associated with statistically significant and lower export earnings. The study recommends that efforts be directed towards finding ways of stimulating responsible consumption in order to make the provisions of eco-efficient value pay-off.

Keywords: gravity model, climate change, responsible consumption, sustainable markets eco-efficient

5.1 Introduction

The global deciduous fruit industry has experienced an increase in international trade due to improvements in logistics, trade liberalisation, advances in information technology and developments in cold chain management (Mashabela and Vink, 2008; Doganay et al., 2014). All these changes have intensified competition pressures for countries to maintain a strong position globalised economy, generating a state of hyper-competition in the market (Codron et al., 2003). The nature and structure of the prevailing business environment have been fuelled by consumers' growing demands for fruit of good quality. These consumer demands have gradually shifted from an expectation of the provisions for perfect fruit (fruit that delivers a good eating experience and is appealing to the senses), to include provisions of fruit whose production also allays concerns on traceability, climate change, carbon neutrality, sustainable production, fair trade and food safety (Loureiro et al., 2002; Curzi et al., 2020). The pressures for products that promote responsible consumption have been noted in numerous studies such as Miles and Kovin (2000), Curzi et al. (2015) and Jouanjean (2012).

Consumers' evolving demands have been buttressed by rising retailer quality standards as well as international trade regulations that have been crafted to make it impossible for profitable international

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trade to take place without full compliance to these new regulations (Jouanjean, 2012). Producers have additionally responded to consumer concerns by providing quality cues which have aided in differentiating products (Loureiro et al., 2002). In the peach and nectarine fruit industry, quality signalling has included the use of food labels indicating the quality-grading awarded to the fruit or specialised packaging that facilitates quality preservation. Food labels such as Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI) certification have been awarded to some products to ratify and endorse the superior eating-qualities in fruit produced or processed in specified regions (Cembalo et al., 2009; Cei et al., 2018). Voluntary labels indicating environmental credence certification have also been used to testify to sound environmental stewardship and compliance to environmental regulations at the farm, packhouse and regional levels (WWF, 2018). New quality management technologies such as Smartfresh™ promise superior eating-quality, environmental stewardship and energy-saving benefits (Smartfresh™, 2017).

Numerous studies (Calvin and Krissoff, 1998; Piveteau and Smagghue, 2019; Curzi et al., 2015) have investigated the role played by product quality in shaping the patterns of trade by utilising product prices. Most of these have encountered various attribution challenges due to endogeneity problems in their regression analyses since changes in price are often associated with various market factors (Piveteau and Smagghue, 2019). Consequently, instrumental variables such as trade regulatory standards have been used to measure a product's ability commonly to meet safety, health, aesthetic, and environmental quality standards (Calvin and Krissoff, 1998). However, the limitation of this measurement proxy is that it relies on institutionalised thresholds and is therefore not sensitive to the varying levels of quality within the acceptable category. Hence, similar to price variables (Curzi et al., 2015), the variable proxies are unable to accommodate a broad scope of quality. This paper provides an alternative means of measuring quality product attributes and uses the derived quality indices to explain international trade flows from the South African fresh peach and nectarine market. It uses indices that were constructed in Manuscript 2 to capture quality resulting from cultivar characteristics in measuring aesthetic fruit quality, supply timing and the overlap between aesthetics and climate change adapted cultivar characteristics (eco-efficient value proposition).

Although the current study measures different aspects of product quality, it is primarily concerned with the impact of the delivery of eco-efficient value proposition which enhances responsible consumption. The study takes this focus as other research continually confirm that striking a balance between sustainable production, consumer satisfaction and profitability is critical to sustainable growth. The study tests the Porter and van der Linder hypothesis (1995) which proposes that an adaptation to consumer demand in an environmentally friendly manner leads to the development of innovations which induce an improvement in production that supersedes the costs of procurement. Hence, the efficiency and

productivity gains trigger innovations that create a basis for trade competitiveness (Hwang and Kim, 2017; Huang et al., 2011). This research posits that eco-efficient value provision in cultivars used in South African exports is the key innovation holding the potential to stimulate exports. The argument in this study resonates with one made in various works in the virtual-trade literature (Fracasso, 2014; Aldaya et al., 2010) which state that agricultural commodities which have higher levels of sustainably sourced water green water (soil water originating from rain) possess a competitive edge over those that are produced using blue water (underground water). A connection is made with this field of virtual water trade as the elements of responsible consumption investigated are not provided on the product and remain unknown to the consumer and other market participants.

The remainder of the study is structured as follows: Section 5.2, below, provides a review of past studies, while Section 5.3 discusses the theoretical background for the study. This section is followed by Section 5.4 that offers a description of the study methodology. This includes the analytical framework, model specification and variable computation and descriptions. Section 5.5 presents and discusses the results. The paper offers conclusions in Section 5.6, where recommendations are also proffered.

5.2 Literature review

The literature on the importance of product quality in explaining trade flows goes as far back as Linder (1961) who identified a link between wealthy countries' high trade activity and the production and consumption of quality goods. Subsequent studies such as those by Schott (2004), Hummels and Klenow (2005) and Fontagné et al. (2008) noted that quality upgrades have been the central stimulus of export increases. Many of the studies in this area of investigation have used firm-level data in constant elastic substitution (CES) specifications applied in demand and/or supply functions. They have also have used price variables to measure quality (Curzi et al., 2015). The variable utilized has posed significant limitations to empirical estimation. Indeed, many such studies have encountered the endogeneity problem due to the relationship that exists between prices and estimation variables (Curzi et al., 2015). Price movements have been associated often with other non-quality related stimuli that have been described broadly as economic, social, market and business shocks (Piveteau and Smagghue, 2019; Roselli et al., 2016). Consequently, results from previous studies have also been integrated in some studies to show a positive relationship between an increase in quality and economic activity while others like (Foster et al., 2008) produced contradictory results.

Product branding statistics different approach that has been used to capture product quality that has gained traction in the past two decades. Branding statistics have been applied at the country level where the terms “national brand image” and “national reputation” promise an expected and unobservable quality of imports (Cage and Rouzet, 2015; Bartlett and Ghoshal, 2000). Studies have confirmed that country-of-origin labelling has had a significant influence on trade-flow (Cage and Rouzet, 2015); however the ambiguous specification of quality and the non-excludable nature of quality cue have often fuelled free-riding and morally hazard behaviour. These ambiguities invariably lead to the erosion of consumer confidence and the weakening of some brands. Hence, industries have acceded to the sui generis legal frameworks that provide a more robust certification of quality using Geographic Indicator certification. Protected Geographical Indication (PGI) or Protected Designation of Origin (PDO) Certification is awarded to products that exhibit superior qualities resulting from production or processing in specified growing regions in a country (Lubinga et al., 2020; Cei et al., 2018). These new quality indicators have also enabled the separation of quality attributed to intrinsic product characteristics and those attributed to collective cultural creation. Although some studies (see for example Barham and Sylvander, 2011; Jena and Grote, 2012; Vandecandelaere et al., 2011) have highlighted concerns of the potential negative effects of exploiting and protecting Geographic Indicators products, an overwhelming amount of evidence shows the economic and welfare advantages of developing and using these quality indicators. For example, Curzi and Olper (2011) found that the use of Geographic Indicators (GIs) had a positive impact on trade performance. Work done by Biénabe and Marie-Vivien (2017) discuss the benefits of institutionalizing a hybrid between public quality standards and specific intellectual property rights to protect a heritage-based reputation on Basmati and Rooibos. Lubinga et al. (2020) found that protected GI certification was effective in enhancing the value of South African wine exports to the European Union market.

The use of GI as a proxy for quality is gravely limited by the fact that very few products which represent a very small proportion of food products trade on global food markets are captured. The use of international trade regulatory standards to measure quality has overcome this limitation. In particular, Sanitary and Phytosanitary standards (SPS) and other Technical Barriers to Trade (TBT) have been used to measure the capacity of products to meet safety, health, consumer aesthetic, and the environment quality (Calvin and Krissoff; 1998). Current evidence on the trade effects of regulatory standards is varied and ambiguous (Curzi et al., 2015). For example, a study by Dal Blanco et al. (2015) found that sanitary and phytosanitary measures did not obstruct exports, while technical regulations had a varying impact on trade. Hwuang and Kim (2017) reported that environmental standards deterred green food trade flows amongst countries in the Organisation for Economic Co-operation and Development (OECD) while other researchers also established that environmental regulations have a statistically significant positive effect on the pattern of exports of OECD countries. The results from a study conducted by Curzi, (2020) show that the effects of trade barriers tend to move from being positive to negative as the regulations become

more restrictive. However, the inconsistency in the findings warrants further enquiry in order to facilitate accurate conclusions.

Despite, the volumes of completed work available, there remains an unmet need for quality differentiation in international trade of high-value agricultural export sectors such as the horticultural produce (Curzi et al., 2020). The relatively higher quality differentiation channels and the rapid increase in quality standards that have been introduced in fresh fruit is testament to this fact. Although studies such as Krissoff et al. (1997), Calvin and Krissoff (1998 and 2005), Yue et al. (2006) and Kapuya (2015) contribute to the empirical evidence in this sector using trade regulation data, they have not captured the intrinsic product attributes. Additionally, this quality proxy relies on institutionalised thresholds and it is not sensitive to the varying levels of quality available within the scope of what is allowed by legislation. These varying levels of quality that are captured in product characteristics are an essential inclusion for trade research as they determine higher economic rewards. The plurality in quality diversity demands such proxies that are more sensitive, capturing the wide scope of quality. Wang et al., (2018) provide an example of a study that acceded to this school of thought, where an index calculated the varying levels of green logistic performance in products. Wang et al. (2018) found that green logistics performance of products from an importing country decreased the probability or volume of export for foreign exporters. This study confirmed a positive relationship between environmental logistics performance and volume of export. Investigations of virtual water trade research such as Aldaya et al. (2010) and Fracasso (2014) share this philosophical argument that agricultural commodities which had higher levels of sustainably sourced water green water (soil water originating from rain) possess a competitive edge over commodities that are produced using blue water (underground water).

More importantly, this approach to product quality attribution to international trade is that it presents an avenue for the calculation of economic returns or costs of an eco-efficient value proposition (sustainable production while meeting consumer's demands). This is an important area of investigation as the three trends (sustainable production, consumer satisfaction and profitability) set the trends in high-value markets and trends seem to show trade-offs between gains (Doganay et al., 2014). As consumer research shows the resistance of markets for the provision of these product values, the absence of a thriving market amplifies the coexistence of the different dimensions (a market for responsible consumption) indicating market imperfection that warrants investigation. The current study measures product quality using the quality characteristics of intellectual property. It takes a similar approach but captures product genetic traits as promoting sustainable production or promoting hedonic value. The study builds on quality characterization that was done by Crozet et al. (2012), who used international product description on the French wine industry in combination with consumer demand. However, the current study makes a contribution as the one conducted by Crozet et al. (2017) did not incorporate eco-efficiency aspects to the quality proxy measured.

5.3 Theoretical background

The provision of an eco-efficient value proposition is expected to improve international trade performance because it provides for sustainable production while delivering consumer value (Michelsen, Fet and Dahlsrud, 2006). This is the expectation from trade patterns as such a proposition stimulates a positive supply-driven response to the effect of innovation on production while the latter explains demand-driven response to innovation. Classical economics explains the supply-side effect as innovation mediates harsh production conditions. The introduction of innovations induces an improved production that supersedes the costs of procurement. Hence, the efficiency and productivity gains trigger innovations that create a basis for trade competitiveness (Porter and Van der Linde, 1995; Hwang and Kim, 2017; Huang, Lampe and Van Tongereen, 2011). The Ricardo model and the Heckscher–Ohlin–Samuelson models posit that the production advantages that result from the use of adapted technology re-balance relative differences in factor productivity between countries and this makes countries with relatively higher adaptive technology to specialize in the production of goods that intensively utilize the available technology (Bestbier, 2016; Kerr, 2013). Therefore, this supply-side view predicts that a comparative advantage that emanates from the better adaptation to climate change (Huang *et al*., 2011; Doganay et al., 2014; Brown *et al*., 2017).

The neoclassical trade theory predicts that trade flows will respond to demand-driven stimuli or eco-efficient value proposition. This trade theory departs from classical theory and introduces the importance of consumer preferences and how they take higher precedence in determining trade flows (Bestbier, 2016). Therefore this theory implies that there needs to exist a demand for the product which is produced from climate change stimulated innovation and this demand should exist on both the domestic and export markets. In the context of the current study, this implies that an improvement in international trade performance will occur if the demand characteristics that promote sustainable production experienced by the exporting country also co-occur with the organoleptic fruit quality characteristics that are demanded by consumers. Thus, the explicit demand in the domestic market should match the implicit demand experienced in the export market. The Linder hypothesis postulates that the similarity of demand in the exporting countries will stimulate trade in similar but differentiated goods (Ingham, 2010).

Buys, Deichman and Wheeler (2010) warn that the failure to deliver on market expectations may cause a reduction in market participation and may thaw chances of economic integration in regional and international markets. These productivity gains could be eroded by market forces. While the adaption of production systems to harsh production conditions creates climate change's implicit winners and losers, market adjustments to forces of demand and supply tend to provide a second round of climate change effects (Vickers, 2017). O'Brien and Leichenko (2000) states that this double exposure creates double

winners or double losers (O'Brien and Leichenko, 2000). Therefore, according to the predictions of O'Brien and Leichenko (2000), the creation of products that meet both market demand demands and sustainable production demands have the decisive element in eco-efficient production.

5.4 Methodology

5.4.1 Analytical framework

This study uses the gravity model to determine factors that stimulate or deter trade flows in the South African fresh peach and nectarine exports. The gravity model is the mathematical equation that provides an explanation of bilateral trade flows by using an analytical relation that draws from the "Universal Law of Gravitation" proposed by Isaac Newton in 1687. Similar to the Universal Law of Gravitation, which states that, "the attractive force between two objects is a positive function of their respective masses and a negative function of the distance between them", the gravity model states that the export flow of goods and services between two countries is related positively with their "economic mass" (M_i *and* M_j) and negatively with distance (R_{ij}) between them. The gravity model in illustrated in E*quation (5.1)* below:

$$F_{ij} = G\frac{{M_i}^{\alpha}{M_j}^{\beta}}{R_{ij}} \quad \text{.....(5.1)}$$

where F_{ij} are the exports from origin country i to destination country j; M_i *and* M_j are the economic size of the two countries; R_{ij} is the distance between the two countries,; G is a constant that depends on the units used to measure the other variables. The multiplicative nature of the gravity equation means that it is possible to take natural logarithms obtaining a linear relationship between log trade flows and the logged economy sizes and distances as follows:

$$\ln F_{ij} = \alpha_0 + \alpha \ln M_i + \beta \ln M_j - \gamma \ln R_{ij} + \varepsilon_{ij} \quad \text{.....(5.2)}$$

where α_0 is a constant and α and γ are coefficients and ε_{ij} log-normally distributed error term.

Different the variables (trade flow, distance and economic mass) have been measured using different types of data. The trade flows have been measured using the volumes of exported goods or the value of exported goods and services while the economic distance has been measured using time taken to fly or drive taken to travel between the first cities or the number of kilometres between them (Kapuya, 2015). The economic masses have been measured using the Gross Domestic Product of Gross National Product of countries. Over the years, the gravity model has also been augmented in several studies in order to

include various factors that are not captured in the core gravity model. These factors have been interpreted as causing impact competition on international markets and result in increases or a decreases in the economic distance between countries. These augmented models have included different types of factors which are economic (e.g. exchange rate, use of common currency), geographical (e.g. share border, landlocked, location of country), political (e.g. presence trade regulations and agreements), infrastructural (e.g. transport infrastructure quality, percent of roads that are paved and quality of border-station customs services) and demographic (e.g. population) in nature (Rosa, Pinilla and Serrano, 2019; Lubinga, 2014; Frankel and Rose, 1997). By capturing these factors the model has explained trade flows as being a function of the economic, geographical, infrastructural, political and/or cultural distance that exists between countries.

The gravity model has been used for many years and described as the workhorse of international trade analysis due to its ability to explain bilateral trade flows between countries (Buys, 2010; Lubinga, 2014). It has been cited as one of the most robust and widely used tools for empirical analysis of trade flows between countries (Kapuya, 2015). The model possesses several distinct advantages over other comparable Ordinary Least Squares specifications that are used for estimating bilateral trade flows. Firstly, the gravity model requires a relatively limited amount of data; hence, it can be estimated with parsimonious data in contexts where data is scarce and costly to obtain (Erero, 2007). Secondly, gravity models have been improved over time to capture theoretical considerations more amply (Head and Mayer, 2014). Thirdly, the gravity models can estimate trade flows that reflect the influence of trade-enhancing and trade-inhibiting effects of various dynamic micro- and macro-economic factors (Kapuya, 2015). This is the key reason why the model is identified as one of the most useful empirical tools in estimating the cause-effect relationship between the identified factors and trade volumes.

5.4.2 Gravity model specification

This investigation utilises the gravity model and incorporates product quality characteristics, tariffs, and demographic, demand and economic indicators to explain trade flow. The study utilized panel data spanning from 2001 to 2017 which consisted of the top 21 countries to which South Africa exported during the period under study. It was made up of the United Kingdom, Russia, Hong Kong-China, four European countries (Netherlands, France, Germany, Ireland), nine African countries (Angola, Eswatini, Mauritius, Mozambique, Namibia, Botswana, Zimbabwe, Zambia, Egypt), and five countries from the middle-east (Bahrain, Saudi Arabia, Kuwait, Qatar and United Arab Estates) *Equation 5.2* represents the gravity model that was estimated. It shows the factors that influence South African fresh peach and nectarine exports.

$$lnExports_{ijt} = \beta_0 + \beta_1\ Eco\text{-}Efficiency_Index_{ijt} + \beta_2\ Quality_Index_{ijt} + \beta_3\ Supply_Index_{ijt} + \beta_4\ lnImport_Propensity_{ijt} + \beta_5\ lnSA_GDP_{ijt} + \beta_6\ lnDistance_{ijt} + \beta_7\ lnImporter's_GDP_{ijt} + \beta_8\ Tariff_{ijt} + \beta_9\ NTBs_{ijt} + \beta_{10}\ lnImported_Varieties_{ijt} + \beta_{11}\ lnPopulation_importers_{ijt} + \beta_{12}\ Colonial_Ties_{ij} + \varepsilon_{ij} \quad (5.3)$$

where $lnExport_{ijt}$ is the natural logarithm of the dollar value of the annual exports of South African fresh peaches to its trading partners; $Eco\text{-}Efficiency_Index_{ijt}$ is an index measuring the effect of improvement on delivery of eco-efficiency product value in South Africa's annual, fresh peach and nectarine exports, $Quality_index_{ijt}$ is an index measuring an improvement in perceivable or aesthetic fruit traits in South Africa's annual, fresh peach and nectarine exports, $Supply_Index_{ijt}$ is an index measuring improvements in the delivery of off-peak fruit in South Africa's annual, fresh peach and nectarine exports, $Import_Propensity_{ijt}$ is the natural logarithm of the value of total imports from the Southern Hemisphere in real terms and measures the propensity for South Africa's trading partners to import peaches and nectarines, $lnSA_GDP_{ijt}$ is the natural log of Gross Domestic Product of South Africa; $lnDIstance_{ij}$ in the log of the flight distance in kilometres between the capital city of South Africa and that of an importing country + $lnImporter's_GDP_{ijt}$ is the natural log of Gross Domestic Product of an importing country; NTB_{ijt} is the number of non-tariff regulations introduced since 1998 that are faced by South Africa in each international market as imposed by each country, $lnImported_Varieties_{ijt}$ is the natural logarithm of the annual fruit volumes accounted to foreign-bred cultivars, *lnPopulation_importers* is the natural logarithm of total annual population of South Africa's trading partners, $Tariff_{ijt}$ is the number of tariff lines imposed on South Africa's peaches and nectarines, $Colonial_Ties_{ij}$ is a dummy variable scored as 1 if the trading country has colonial ties with South Africa and 0 if otherwise, and εij is a log-normally distributed error term.

5.4.3 Model selection

The study ran the gravity models using three static regression model estimators. These were the standard Pooled Ordinary Least Squares (POLS), the Fixed Effects (FE), and the Random Effects (RE) estimators. The POLS is a restricted model that assumes a single intercept and that there is homogeneity in cross sessions. Therefore this model assessed the aggregated trade flows without taking into consideration the different conditions across time and countries. The latter two models are referred to as unrestricted models as they assume that there is heterogeneity in the data cross-sections. The RE model also acknowledges heterogeneity of countries, but differs from the FE model because it assumes that the effects are generated by a specific distribution. Although this model acknowledges differences in countries, it does not model each effect separately. Therefore FE model is unique in that in estimates the country specific effects. However, it is unable to estimate the effect of time invariant factors that are estimated by the RE and POLS models.

In order to determine the model that best explained the trade flow, the study used the Hausman and Breusch-Pagan tests. The Breusch-Pagan test was used to determine whether a trade flows were best explained using a restricted (POLS) model or an unrestricted model (RE). In the null hypothesis of this test, it is assume that there is no heterogeneity in the data of countries importing from South Africa while the alternative states there are random effects in the data for the importing form South Africa. The Hausman test was used to determine whether the FE or RE model was appropriate in explain the flow of trade from South Africa to its trading partners. The Hausman test specification is applied to test the null hypothesis that the regressors and individual effects are not correlated and to distinguish between fixed and random effects. Failure to reject the null hypothesis means that the RE model explains the trade flows better than the FE model.

Table 5.1 provides a short description for each of the variables.

Table 5.1: Summary of model's variable descriptions

Variable	Description	Source
LnExports	Natural logarithm of South Africa's real fresh peach and nectarine exports	International Trade Centre
Eco-efficient Index	An index measuring the effect of improvement on delivery of eco-efficiency product value in South Africa's annual, fresh peach and nectarine exports	Derived
Quality Index	An index measuring an improvement in perceivable or aesthetic fruit traits in South Africa's annual, fresh peach and nectarine exports	Derived
Supply Index	An index measuring improvements in the delivery of off-peak fruit in South Africa's annual, fresh peach and nectarine exports	Derived
LnImport_Propensity	Natural logarithm of real values of imports from the Southern Hemisphere	World Bank Development Indicators
LnSA_GDP	The natural log of Gross Domestic Product of South Africa	World Bank Development Indicators
LnImporter's_GDP	The natural log of Gross Domestic Product of an importing country	World Bank Development Indicators
Non-Tariff Barriers	The number of non-tariff regulations introduced since 1998 that are faced by South Africa in each international market as imposed by each country	International Trade Centre
LnImported_Varieties	Natural logarithm of the annual fruit volumes accounted to foreign-bred cultivars	HORTGRO
LnPopulation_importers	Natural logarithm of total annual population of South Africa's trading partners	World Bank Development Indicators
$Tariff_{ij}$	Number of tariff lines imposed on South Africa's peaches and nectarines by specific countries	International Trade Centre
Colonial Ties	Dummy variable captured as 1 for country which colonized South Africa	N/A
LnPopulation_importers	The natural logarithm of total annual population of South Africa's trading partners	World Bank Development Indicators
LnDistance	The log of the flight distance in kilometers between the capital city of South Africa and that of an importing country	CEPII

5.4.4. Quality estimates

Quality variables used in this paper were derived in Chapter 3 (Manuscript 2). These indices were derived through the weighting of cultivar characteristics describing consumer organoleptic (perceivable, aesthetic and eating) quality demands with characteristics that promote sustainable production. The study verified that the industry offered three type of value positions articulated as quality-differentiation, eco-efficiency differentiation and off-season supply timing differentiation qualities. These value propositions are captured as time series variables; *Sustainable Consumption Index*, *Quality Index* and *Supply Index. Equation 5.3* below illustrates how these composite indices were constructed.

$$\text{Index} = \sum_{i\text{-}n} \alpha_{ij}\, x_{i\text{-}n} \tag{5.3}$$

where $\sum$ is the sum of the factor scores $x_{i\text{-}n}$ which indicate a measure of value allocated cultivars *i* to *n* which are used for export during year *j* and α_i denotes the proportion of use of a cultivar *i* used for export which as hat is used during year *j*. As explained by Badu and Sanyal (2014), value scores are the scores are derived as shown in *Equation 5.4.*

$$X_i = A_{i1}F_1 + A_{i2}F_2 + \cdots + A_{ik}F_k + U_i \tag{5.4}$$

where *X* is the score of a cultivar *i*, *Fs* are the common factors, *U* is the unique factor, and the *As* are the coefficients of loadings used to combine the *k* factors. The unique factors are uncorrelated with each other and with the common factors. The factors in turn are inferred from the observed or latent variables and are estimated from the linear combination of the variables. These observed or latent variables are cultivar characteristics denoting organoleptic product values (fruit size, skin colour, fresh colour, fresh texture, supply timing) and characteristics that promote sustainable production (growth habit and chilling unit requirement). Hence a factor *k* can be expressed as:

$$F_k = W_1X_1 + W_2X_2 + \cdots + W_pX_P \tag{5.5}$$

The dominance in the expression of a combination of characteristics in factor *k* determines the type of value proposition provided by the subsequent composite index.

5.5 Results and discussion

5.5.1 Univariate characteristics of variables

An analysis of the univariate characteristics of the scale variables was conducted prior to estimating the gravity model. All scale variables are tested for stationarity. The two different panel unit root tests used to test for stationarity are: Levin, Lin and Chu (LLC) (2002) and the second is the Im, Pesaran and Shin (IPS) (2003) tests. The former tests for stationarity assuming autoregressive parameters were assumed to be common across cross sections while the later assumes heterogeneity across panels. According to the results shown in Table 5.2 all tested variables were found to be stationary when the autoregressive parameters were assumed to be common across cross sections. The variables were differenced once before tests were conducted. However, the variables lnExports, lnImporter's_GDP and lnPopulation_importers were non-stationery when they were tested for heterogeneity across panels. These variables were included in the analysis as Jordaan and Eita (2007) report that this a sufficient criteria.

Table 5.2: Summary results of univariate tests

Variable	Levin, Lin and Chu (LLC)	Im, Pesaran and Shin (IPS)
LnExports	-2.7904* **	-1.5450
lnEco-efficiency_ Index	-4.7157***	-6.6881***
Quality_Index	-5.0690***	-7.2350***
Supply_Index	-9.9018 ***	-7.2848***
LnImport_Propensity	-5.9299 ***	-6.8754 ***
LnSA_GDPi	-8.9728***	-6.0112***
LnImporter's_GDP	-2.5533***	2.0936
LnImported_Varieties	-11.9054***	-11.2342***
LnPopulation_importers	-4.2756***	12.9525

Source: Author's calculations
Note */**/*** Denote stationarity at 10%/5%/1% significance level

5.5.2 Empirical results

Three static gravity models were estimated. These were the standard Pooled Ordinary Least Squares (POLS), the Fixed Effects (FE), and the Random Effects (RE).

Table 5.3 reports the findings of the three models that were estimated using the Pooled Ordinary Least Squares (POLS), Random Effects (RE) and Fixed Effects (FE) models. As shown, a p-value of 0.000 was acquired for the Breusch-Pagan LM test. The result of the test rejects the null hypothesis of equality of the individual effects. This implies that a model with individual effects is more appropriate than the pooled model. The POLS model is rejected as a suitable model to explain the trade flows. The table shows a p-value of 0.9643 was acquired for the Breusch-Pagan LM test. Therefore the study determines the RE model is the most suitable model to explain the trade flows. This finding is quite different from past research findings (Kapuya, 2015; Crozet et al. 2012) that showed that idiosyncratic demand plays an important role in determining export. It argues that time invariant factors have an effect on trade flows.

The results are shown in Table 5.3 below.

Table 5.3: Gravity model estimation

	Pooled Ordinary Least Squares (POLS)		Random Effects (RE)		Fixed Effects (FE)	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Eco-efficient Index	-0.0147555**	0.025	-0.019564***	0.000	-0.204987***	0.000
Tariffs	-0.7591394***	0.000	-0.7575842***	0.004	-	
Quality Index	0.0053709	0.655	0.0038181	0.614	0.0054581	0.475
Non-Tariff Barriers	-0.0345264***	0.000	-0.0557022***	0.000	-0.0648979***	0.000
Utilization of imported varieties	0.5020446	0.224	0.73725***	0.002	0.7979272***	0.001
Population of importers	0.4616224***	0.000	0.3886826***	0.002	0.2794115	0.101
Colonial Ties	2.162424***	0.000	2.564832***	0.001	-	
SA_GDP	2.249248	0.466	3.860904***	0.043	3.968629**	0.037
Importer's_GDP	1.316281***	0.000	1.375454***	0.000	1.285974***	0.002
Supply Index	0.0041165	0.722	-0.0009157	0.897	0.0004219	0.952
Distance	-0.7593609***	0.000	-0.7265199**	0.015	-	
Import_Propensity	0.0000127	0.258	0.0000117*	0.086	0.0000119***	0.0080
Constant	-27.58447	0.319	-42.10368**	0.014	-47.15186***	0.007
Observations	329		329		329	
rho			0.61973769		0.84857864	
R squared within panel			0.40		0.40	
R squared between years			0.64		0.24	
R squared overall	0.6059		0.59		0.29	
F test p-value			0.000		0.000	
Breusch-Pagan LM test	0.000					
Hausman test p-value	0.9643					

Source: Author's calculations
Note */**/*** Denote stationarity at 10%/5%/1% significance level

The results from the estimates of most of the individual regressors shown in Table 5.3 were in line with economic theory and past empirical studies. As expected an increase in the distance between trading partners was associated with a decrease in trade flow. This is because the further away country is, the more expensive it is to export to that market. Hence, this increase in cost renders the exporting country less competitive in that market as compared to the closer nations and this results in a reduction in participation in that market. This result is consistent with the findings of a study that was conducted by Melo et al. (2013). This study found lower trade flows of Chilean fruit to be as a result of higher costs owing to the longer traveling distance. According to Emlinger et al. (2008), distance is also a trading resistance factor that represents trade barriers such as transportation costs, delivery time, cultural unfamiliarity and market access barriers. Lubinga (2014) reports that distance can also indicate the risks associated with the quality of some of the goods and the cost of the personal contact between managers and customers. All these cause reductions in reduce trade volumes and hence cause lower export earnings.

As expected, an increase in Gross Domestic Product in South Africa was associated with an increase in export revenue. This result can be illustrates a positive supply effect of wealth on international trade. An increase in a country's wealth causes an increase in production capacity in the exporting country and this causes an increase in trade volumes (Zhang et al. 2018; Kapuya, 2015), and hence an increase in export earnings as shown by the results. The results in Table 5.3 also showed that an increase in the Gross Domestic Product in the importing country led to an increase in export earnings for South Africa. This result illustrates a positive demand pull effect on trade where the citizens in country become relatively more disposable income and this causes them to demand higher quantities of the good that is imported (Lubinga, 2014; Zhang et al., 2018). Hence an increase in volumes traded results in an increase in export earnings shown in the results.

The RE model predicted that every 1% increase in the Gross Domestic Product of South Africa is associated with a 2.25% increase in trade earnings. A 1% increase in the Gross Domestic Product of an importing country is associated with a 1.3% increase in trade earnings ceteris paribus. This result is supported by the findings of De Paul and Ching-Cheng (undated) who reported that the coefficients on importer's and exporter's GDPs tend to be higher than one. As the study found coefficients greater than 1, then this implied that the supply and demand fresh peach and nectarines is elastic.

As shown in Table 5.3, an increase in the import propensity for Southern Hemisphere peaches and nectarines by South Africa's trading partners was associated with an increase in export earnings. However the margin of gain associated with an increase in consumer propensity to import Southern Hemisphere fresh peaches and nectarines is very small. This shows that South Africa benefited from the increasing demand for out-of-season fruit in the export market. The results imply that South Africa fares competitively in the international market, as an increase in exports from the competitors did not negatively affect the export performance of South Africa. This result is similar to the finding of Melo et al. (2013) who found that another Southern Hemisphere dominant country, Chile, had fresh fruit fared well in the global market.

The results show that an increase in Eco-efficient Index is associated with a decrease in export earnings. This means that the industry is experiencing a negative-end game as it is bearing the cost of climate change adaptation. This result is consistent with the findings of Rosa et al. (2019) who found that sustainable production and consumption was not positively associated with increases in trade flow. This finding is not alarming as the index that measured this value proposition showed strong correlations with yellow-fleshed fruit varieties. The yellow-flesh fruit type is decreasing in demand (Layne and Bassi, 2008) because consumers associate the alternative flesh colour (white-flesh) it with superior aesthetic qualities and social values (Zu-Hua and Zhen-Xiang, 1992; Maloney, 2006). Linder's hypothesis explains that climate-adapted innovation can only pay-off if it satisfies critical requirements of consumer demand.

Buys et al. (2010) reports that failure in significant market response is often attributed to the failure to deliver on the market's expectations. Hence, this finding suggests there is need for product repositioning in order to increase sustainable consumption in this industry.

As shown, an increase in the population of the importing countries was associated with an increase in export earning in South Africa's peach and nectarine fresh exports. An increase in population often represents a natural increase in customers. In the absence of new influential trends, these often predicted to lead to an increase the increase the prevailing demand patterns. The results in Table 5.3 also show that an increase in the use of imported cultivars was associated with an increase in South Africa's export earnings in this industry. This is because these imported cultivars more readily meet the consumer preferences. In addition, the consumers in South Africa's export market are more familiar with the imported cultivars as these are produced in their countries. According to Byrne (2002), the Calfonia bred cultivars have the highest area production on the global market and these tend to attract more demand due to consumer familiarity. The locally bred varieties are often bred to meet the sustainable production requirements in South Africa and do not acquire the higher production area and subsequently have lower self-space in retail market as compared to the non-South African cultivars. This finding corroborates with economic trade theory that points out product familiarity as one of the major driving factors affecting trade flows (Fracasso, 2014; Cantore et al., 2014). This finding is equally supported by Calvin and Krissoff (1998) who concur with the perception that export growth could be associated with preference for specific cultivars in the fresh deciduous fruit industry. According to Zhang (2020), these preferences tend to be strongly associated with the food brands and varieties which they are familiar with rather than those that have a foreign origin. Another study with found similar results was carried out by Melo et al. (2013). It showed that consumer preferences had a very strong influence on the demand for Chile's fresh fruit on international markets.

As shown in the results, export earnings were negatively associated with increases in tariff lines and increases in the number of non-tariff barriers. These factors discourage trade as they are often associated with higher costs of inspection and compliance. A higher number of this compliance lines is also associated with time lost in administration and information search costs. Therefore, a country would rather export to a market with a lower number of non-tariff barriers and/or tariffing lines. This result is similar to the findings of Melo et al. (2013) and Dal Bianco et al. (2020) who also found that non-tariff barriers had a negative effect on trade expansion. Kapuya (2015) also found that South African fresh orange exports decreased by 1.4% with every percent increase in the tariff equivalent of technical barriers. Different from Kapuya (2015), the tariff paused a greater hindrance to export growth than the non-tariff barriers.

5.6 Conclusion

The paper sought to investigate the effects of product quality in exports. This was done by differentiating different quality attributes using the three product value propositions (Eco-efficiency, Quality and Off-peak supply) that form the main descriptors of quality in the South African peach and nectarine fresh exports. The study contributes to international trade literature in using such a classification of quality.

The study's findings showed that the quality improvements did not stimulate trade flows in South Africa's peach and nectarine fresh market. This was a surprising finding as the export strategy for South Africa is built around the investigated quality aspects. Instead, exports were driven by income growth in the country well as importing country, arrangements with countries with colonial ties, the trading partner's population growth, the use of imported cultivars and the consumers' propensity to import the product during the Northern Hemisphere's off-season. These factors assisted marginally competitive and were not negatively affected by the competitors from the Southern Hemisphere. Tariffs and non-tariff barriers impeded the increase in growth of export earnings as expected. It is concerning that there was a negative association between the growth of export earnings and the Eco-efficient Index. This demonstrates that sustainable production could remain a cost that is borne by suppliers.

As the study showed that the results did not apply to specific counties but to groups within the dataset, it points out the severity of negative end game that is experienced in the industry. The paper demonstrated that if not marketed as an additional value (as shown the Eco-efficient Index) and it can also be a hindrance to gaining significantly larger export earnings if disregarded as demonstrated by the Quality Index. In much the wide effect of the cost of sustainability presents a threat that is cutting across the industry, it also presents an opportunity for market development and value creation. Therefore the results in a different light, highlight the need for the South African industry to develop innovative ways to communicate their value propositions to provide a way and facilitate an increase in trade and subsequent increases in the derivation of higher dividends for industry. The response to the provision of a superior value proposition is likely to improve if the consumers are made aware of its presence. However, product repositioning of selected cultivars such as fruit varieties that enable sustainable consumption shall be required as the yellow-flesh traits are currently associated with lower demand trends. Further research would be required for the identification of these cultivars and markets which naturally have a taste of the quality characteristics. This would ensure that there is a match between the gains in climate change adaptation and consumer tastes that has been proven to cause sustainable growth in exports.

CHAPTER 6

Identifying cultivars for eco-efficient market strategies for South Africa's fresh peach and nectarine exports

Abstract: *This study sought to identify markets that could promote eco-efficient value in South Africa's fresh peach and nectarine exports. This is done by first using cultivar attributes to determine core value propositions of the industry and then using the dominant product-dominant country matrix to determine the market opportunities of the industry's global markets. The results show that the provisions of eco-efficient value have the potential to revive growth in South Africa's key, dominant, and declining markets and stimulate growth in new markets. The study's findings also show the existence of a resolute market that demands the provision of aesthetic value and eating-quality in the Eastern Hemisphere. While the first finding provide a basis for motivating value-orientated investments, the second shows significant potential for trade to markdown production sustainability. The study provides recommendations on how incentives could be structured in order to direct the market towards sustainable oriented decisions.*

Keywords: Consumer value, multivariate analysis, climate change adaptation, responsible consumption, ambidextrous strategy, international competitiveness

6.1 Introduction

Changing market and production environments have highlighted the need for the development of eco-efficient value chains. Such chains that promote sustainable production while continuing to provide consumer value (Michelsen, Fet and Dahlsrud, 2006). The conundrum that exists with the establishment of eco-efficient value chains is that these two dynamics are not always complementary to each other. For example in the fresh fruit industry, there is often a trade-off between cultivar characteristics that promote the sustainable use of resources with those that promote consumer satisfaction (Park and Florkowski, 2003; Cembalo, Cicia and Giudece, 2009). Similarly, competition on global markets often makes it difficult to identify cultivars that concurrently promote the economic viability of the farming business and meet consumer demands (Huysamer, 1997). Consequently, the conflicting consequences of cultivar selections often pose a challenge to the achievement of concurrent improvements in sustainable production and market performance.

For demand-driven and high-value industries such as the fresh deciduous fruit export sector, it has been acknowledged that a fruit's perceivable attributes are bred to satisfy consumer expectations which are rated on the basis of their overall popularity and acceptability (Stone and Sidel, 2007; Vietoris, Balková, Czako and Bojňanská, 2015; Cirilli, Bassi and Ciacciulli, 2016; Jaeger, Hort, Porcherot, Ares, Pecore, and MacFie, 2017). An understanding of the way in which this market function has driven the carving of marketing strategies around product value propositions which are based on perceivable fruit traits. These are often classified as intrinsic value traits (taste, firmness, crispness, juiciness and flavour), extrinsic value traits (fruit colour, shape and size) and post-harvest potential (shelf-life) (Harker, Gunson and

Jaeger, 2002; Delgado, Crisosto, Heymann and Crisosto, 2013). In a study on fresh peach and nectarine markets, Zu-Hua and Zhen-Xiang (1992) identified six sensory classifications (crisp, honey, juicy, flat, nectarine and yellow peach) around which countries have crafted their export strategies. These have been utilised particularly by Argentina, that has built its competitiveness around quality (Huysamer, 1997). Canada has developed the Calanda Protected Destination certification, which boasts of the superior fruit quality produced in designated areas (Groot and Albisu, 2015). For other countries, the provision of good quality fruit is often regarded as key to fresh fruit market participation, while other additional factors determine competitiveness (Curzi et al., 2020). For example, Chile remains competitive on the global deciduous fruit market due to the economies of scale gained through its export of large quantities of fruit (Huysamer, 1997). Another example is South Africa which also utilises off-peak fruit delivery as a strategy to access its most lucrative peach and nectarine markets (the United Kingdom, the Netherlands, the United Arab Emirates, Saudi Arabia, Hong Kong-China, France and Germany) (Ntombela and Moobi, 2013). European countries, on the other hand, have used place-branding to appeal to peach and nectarine consumers (Cembalo et al., 2009). However, export strategies currently remain focused on the assurance and preservation of fruit eating-quality.

Recent research has shown that consumer demands for other non-hedonic traits have been increasing and these have significantly modified the nature and structure of demand for fresh fruit (Byrne, 2002; Cembalo et al., 2009; Santeramo and Lamonaca, 2020). The increasing evidence and awareness of the adverse effects of climate change has motivated consumers to demand products that are produced in a way that causes minimal harm to the environment, but still meet their quality demands. On the other hand, concerns of fairness and good governance have seen consumers increase their demand for products that additionally promote fair pricing and fairness in remuneration along the value chain. In response to the evolving customer requirements, numerous ethical certifications have been developed to indicate product adherence to standards such as environmentally friendly production and social compliance requirements. Despite the growing patterns in consumer value shifts, research has lagged behind in designing strategies that could appeal these distinct value orientations in the peach and nectarine industry. Further, the link between such strategies and the availability of cultivars to implement them remain under-investigated. This is the gap in literature this article aims to fill. David and David (2015) recommend that such research matching industry resources and consumer orientated strategies be done when the business environment is characterised by diversified and volatile customer preferences and transient technologies. Such an approach provides a relatively secure foundation for formulating strategy (David and David, 2015). According to Shankarmahesh et al. (2006) the role of export research is to choose strategic sectors for export promotion and to allocate limited resources.

An examination of the sustainability of the current markets is important in establishing the consequences of customers' decisions regarding the proliferation of characteristics that promote sustainable production.

According to Sansavini et al. (2005), such research that utilizes the Resource Based View approach to investigate the creation of sustainable markets enables the deciduous fruit industry to avoid regrettable scenarios where profit-oriented strategies are implemented at the expense of the environment as experienced in the alpine, foothill and mountain districts in Europe. According to Vurro, Russo and Perrini (2009), examining the interactions of diversified product attributes is key in value chain analysis as it provides broader insights into the evolution of food systems and may foretell of future growth opportunities by projecting emerging, absent or missing markets. Studying the delicate balance between the underlying product-attributes may also indicate of the costs that would be associated with ensuring the survival of the industry in the dynamic global business environment (Beverland, 2014).

The remainder of this paper is structured as follows: Section 5.2 describes the theory that has been used in the study to characterise the factors that drive the emergence value for environmentalism in cultivar selection. The following section reviews past studies that have investigated the relationship between cultivar characteristics. Sections 5.4 and 5.5 describe the analytical procedures and the study's methodology, while Sections 5.6 and 5.7 provide the results and discussion respectively. Section 5.8 proffers a conclusion derived from the paper's trajectory and findings.

6.2 Theoretical Framework

Several theories have been used to explain the influence of human values in guiding the consumer's behaviour. Examples of these include Ajzen's (1991) theory of planned behaviour, Schwartz and Boehnke's (2004) theory of human values, and Fishbein and Ajzen's (2010) theory of reasoned action. In recent years, researchers have increasingly used Stern's (2000) theory of value belief norm theory of environmentalism to explain the patterns determining consumer behaviour in relation to its effects on sustainability. This theory describes consumer demand for sustainable products as depending on the level of influence of three value orientations: egoistic values (values that cause people to focus on maximising individual outcomes based on self-interest), altruistic values (values that draw people to act based on concern for the welfare of others), and biospheric values (values that stem from concern for the welfare of the environment). These value orientations occur in varying proportions from individual to individual.

An altruistic value orientation is driven by a concern for the state of society and ideas of equality, world peace, and social justice (Schwartz and Boehnke, 2004). Consumers exhibiting this as a dominant orientation tend to be concerned for, and take action to promote, the welfare of people outside of their social reference group. The actions of these consumers include purchase decisions against the exploitation of participants in the agricultural value chain, whose operations may include the use of child labour, low farm wages, low remuneration for farmers and exclusion from markets. According to Stern (2000), altruistic behaviour often occurs in response to personal moral norms that are activated in individuals who

believe that particular conditions pose a threat to others, and that their choice of action could either mitigate or avert those consequences.

Consumers with a biospheric value orientation have an emotional affinity towards nature and they value items predisposed towards unity with nature, protecting the environment, and ineluctable beauty (Schwartz and Boehnke, 2004). According to Stern (2000), this value orientation is built on the premise that human activity and a fragile biosphere are inextricably connected. Hence, consumers with an environmental value orientation tend to consider the effects of their purchase behaviour and are likely to be motivated by quality cues that link production systems to environmentally friendly protocols.

An egoistic value orientation is characterised by a relentless pursuit of self-interest. Consumers with this as a dominant orientation are often motivated by the utilitarian or hedonic values that a product provides in meeting their personal needs and wants. According to Stern (2000), this behavioural orientation tends to be contradictory to altruism and biospherism. Mueller (1986) explains the level of antagonism in society as being divided into adaptive (socially conditioned) egoism and rational (intentional) egoism. Such differentiations allow for the identification of products and markets that further the agenda of environmentalism.

6.3 Review of previous studies

Previous studies have used multivariate statistical techniques to characterise consumer value orientations in the fruit industry. Most of these methods used in the global peach and nectarine industry have investigated the correlation of fruit characteristics and consumer orientations. The characteristics that have been considered include fruit size, sugar content, flesh texture, skin colour, and acid/alkaline content (Delgado et al., 2013; Groot and Albisu, 2015). These studies have largely been done in response to consumers' complaints about the high inconsistency in the occurrence and co-occurrence of the sensory or organoleptic characteristics which have resulted in low peach consumption rates (Crisosto, Crisosto, Echeverria and Puy, 2006; Cirilli et al., 2016). Hence, most studies have been done to remedy consumer dissatisfaction by matching the highest valued fruit characteristics to corresponding market segments, as the genetic make-up of the product is limited in delivering on all consumers' expectations. Preference mapping has been applied in such studies to determine the fruit characteristics that should take priority during fruit breeding, production and marketing. Examples of analytical methods that have been utilised in this area of study include principal component analysis, factor analysis, cluster analysis and analysis of variance. Preference mapping and organoleptic classification research studies have greatly enhanced the industry's marketing and promotion activities, facilitating its global expansion through the discovery of consumers in novel and niche markets, and formerly unreached societal strata and demographic groups (Crisosto et al., 2006; Crisosto, 2002). According to Tarea, Cuvelier, and Sieffermann (2007), sensory

evaluation studies continue to be done in order to ensure the maintenance of sensory quality and to investigate approaches to increase fruit consumption.

A revived interest in analysing cultivar trait interactions has arisen due to fears of the negative implications that could result from the disbandment of protectionist trade policies and the introduction of non-tariff trade barriers (Stone and Sidel, 2007). Such developments in the global market have significantly altered the market landscape through the removal of unfair competitive advantage to some participants (in the former case) and restriction of access to selected markets (in the latter case). Therefore, changes in the governance structure in the global market have shifted the focus of country competitiveness from being less reliant on policy, and more on the delivery on the precise values of consumers. These shifts in the market have sparked interest in evaluating the interaction between value delivery and price and/or other market performance indicators. Investigations of such a nature have used the above mentioned analytical methods and also included the use of latent class testing and regression analysis. The most popular analytical technique has been the willingness-to-pay method, which has sought to assign an economic value to latent characteristics. Other studies such as the one conducted by Park and Florkowski (2003), have used preference mapping to identify the impact of farmers' quality preferences on technology adoption.

In recent times, the preference mapping technique has also been utilised to investigate the relationship between sensory quality traits and new credence indicators that indicate environmental impact, food safety, and product origin value (see Cembalo et al., 2009; Santeramo and Lamonaca, 2020). An example of a study that has probed these novel issues is one conducted by Tarea et al. (2007), which investigated the trade-off between the sensory and nutritional value of fruit. A study by Cembalo et al. (2009) investigated the trade-off between country-of-origin, price, and organic production system. According to the researcher's knowledge, no study has been done that uses fruit characteristics to evaluate the relationship between organoleptic traits and sustainability traits. At best, the closest has been a study by Crisosto (2002) that determined the relationship between harvest timing and seasonality to the traditional value indicators.

The present study therefore makes a methodological contribution to literature as the present study uses secondary data. This is different past studies used primary data, to analyse the actual consumer preferences in South Africa's export market. The utilisation of secondary data is instrumental in overcoming some of the prominent limitations that researchers encounter during preference mapping as detailed by Harker et al., (2002). An example of these limitations is the lack of sample representativeness. This is often experienced in cross-sectional data samples where the number of respondents are restricted due to resource scarcity. Additionally, data collection that uses recall methods often limits the robustness of data as respondents often exhibit selective bias in their responses due to the time lapse between fruit consumption and data collection. Further, this study also addresses the shortcomings of using an

experimental methodology which is associated with sourcing of samples that have a comparable level of maturity and thus introducing bias into the data.

6.4 Analytical method

This study used multivariate analysis to investigate the existence of eco-efficient market segments for South Africa's peach and nectarine fresh exports, and to identify the cultivars available to serve them. This two-step approach employed exploratory factor analysis and cluster analysis. The former method was used to determine the number of market segments and strategies in the market. This contingent valuation method was used due to its ability to address the limitations of market approaches which are often restricted to applying one-dimensional value constructs that sum a good's value in its price. According to Di Franco and Marradi (2013), factor analysis allows the use of proxies that reflect or estimate the value associated with non-market attributes. These are often correlated and latent in nature. The analysis detects the structure in the relationships between underlying latent variables and performs an orthogonal procedure which transforms them into linear combinations of uncorrelated variables (called factors) (Fraix-Burnet, Thillard and Chattopadhyay, 2015; Di Franco and Marradi, 2013). According to Fraix-Burnet et al. (2015), the strength of this analytical tool lies in its ability to capture the complexity of diversified matters.

The study extracted factors by using the principal axis factoring method because it is the variation of factor analysis that is best-suited for detecting structure in the relationships between variables and in classifying variables (Di Franco and Marradi, 2013). The acquired factors were rotated using the varimax rotation method that maximises the variance (variability) within the derived factors while minimising the variance between Factors (Di Franco and Marradi, 2013). This is different from comparable methods (e.g. quartimax) that minimise the variability within the factors and achieve higher factor loading values. Deriving uncorrelated factors is instrumental for this study as this is a prerequisite for deriving market segments.

A loading score threshold of 0.3 was used due to the exploratory nature of the study. According to Costello and Osborne (2005), this is the lowest acceptable loading and is utilised during exploratory research. The Kaiser–Mayer–Olkin (KMO) and Bartlett's sphericity tests were used to assess the suitability of the underlying variables for factor analysis. According to Hair, Black, Babin, Anderson and Tatham (2006), variables are considered suitable if the KMO values are greater than 0.5 and Bartlett's sphericity test is statistically significant at $p < .05$. Factors with eigenvalues equal to or greater than 1 were retained, following the example provided by Jolliffe (2002).

The variables generated from the factor analysis were used to carry out cluster analysis. K-means cluster analysis was used to split cultivars according to the identified strategies. This method allocates a set of

individuals/observations to a set of mutually exclusive groups (Fraix-Burnet et al., 2015). The matching of the groups of cultivars with the market strategies determined in the preliminary analysis was done in order to draw inferences about the industry's ability to serve the derived market strategies. Cluster centre weights were used to determine the allocation of cultivars groups to different market strategies. Analysis of variance (ANOVA) was used to detect significant matches between market segments and the clusters of cultivars. As affirmed by Ares and Gambaro (2007), the ANOVA set is appropriate for the allocation categories of products to utility classifications.

6.5 Data

6.5.1 Data sources

This study used cultivar descriptions collected from the Plant Breeders Rights registries of South Africa's Department of Agriculture, Forestry and Fisheries' (DALRRD, 2019). These constitute a repository of plant intellectual property data conforming to a format stipulated by the International Union for the Protection of New Varieties of Plants (UPOV). Other cultivar descriptions were sourced from the Agricultural Research Service's Registries for the US Department of Agriculture. These were recorded in List 35 to List 48 of a publication called the New Fruit and Nut Cultivars List (USDA-ARS, 1991 - 2016). The Agricultural Research Council's (ARC's) technical bulletins and ARC-Culdevco online database also provided cultivar descriptions for the older locally bred varieties (ARC, 2019). As most trait rankings are susceptible to changes in environmental conditions (Mounzer, Conejero, Nicolas, Abrisqueta, Garcıa-Orellana, Tapia, Vera, Abrisqueta, Ruız-Sanchez, 2008; Sarkhosh, Olmstead, Chaparro, Andersen and Williamson, 2016), the cultivar descriptions from the prominent breeders of imported cultivars operating in the local market were also consulted to ensure consistency and reliability of the ranking provided by UPOV and USDA-ARS. Only cultivars that contributed at least 1% of the annual fruit export regime for at least three years between 1999 and 2018 were considered for the study. Thus, the cultivars used in the study accounted for between 80 and 99% of annual export deliveries for the period under analysis. The list for cultivars and percentage contribution to annual exports was calculated from *Key Deciduous Statistics*, a journal published annually by the deciduous fruit growers association called HORTGRO.

6.5.2 The computations quality indicators: Cultivar attribute data calibrations

The cultivar-description data sources utilised in the current study contained between 15 and 67 cultivar trait indicators. Eight cultivar characteristics were used as indicators of consumer value in this study. These cultivar characteristics were: "chilling unit requirement", "growth habit", "harvesting period", "fruit firmness", "fruit shape", "fruit size", "skin colour" and "flesh colour".

Value scores were allocated to the indicators of fruit quality for both sensory and production characteristics through a worst-to-best ranking. This was done in reference to the prevailing market and production expectations as at 2019. Using a 3-point Likert scale, coded 1 to 3, cultivar characteristics' traits were ranked from least to most desirable. A score of 3 implied that the cultivar was rated as having an excellent trait, which enabled the cultivar to be aligned with existing and future market opportunities or production challenges in South Africa. A score of 2 implied that the cultivar was rated as having a good trait, which enabled the cultivar to be adapted to existing market opportunities or production challenges in South Africa. A score of 1 implied that the cultivar did not meet the sustainably-production requirements, but was acceptable for export use, with the caveat that the trait did not enable the cultivar to fare competitively in addressing market and production demands of the prevailing age.

The rankings of the fruit characteristics used in this study are detailed in Table 6.1.

Table 6.1: Cultivar trait ranking criteria

	Traits	Ranked 3	Ranked 2	Ranked 1
1	Chilling unit requirement	Low Chilling requirement <400 Infruitec Chilling Units	Medium Chilling requirement 400 - 800 Chilling Units	High Chilling requirement > 800 Infruitec Chilling Units
2	Cultivar growth habit	Upright	Semi-upright/Spreading	Spreading
3	Cultivar harvesting dates	Very Early and Very Early to Early Very Late and Very Late to Early-Late	Early/Late and Medium-Early-Late	Medium
4	Fruit shape	Broad/Medium Oblate and Flat	Circular and Circular-Oblate	Circular and Circular-Oblate
5	Flesh firmness	Clingstone varieties 13 – 15 lbf	Semi-cling/freestone 10 – 13 lbf	Freestone varieties 6 – 10 lbf
6	Flesh colour	White/ Red	Orange / Deep Yellow	Yellow / Light / Pale yellow
7	Skin colour	Full red / > 75% Blush	20 - 75% Blush / Mixed colour	No / minimal blush
8	Fruit size	Large-Very Large Diameter 68 - 81mm	Medium Diameter 62-68mm	Small-Very Small Diameter 52-61mm

Source: Author's conceptualisation
Note: lbf means pound of force

Two cultivar characteristics, "cultivar chilling unit requirement" and "cultivar growth habit", were used as indicators for sustainable of production. A cultivar with a low chilling requirement is better adapted to the changing climate as it ensures consistently high yields (without the aid of production chemicals) regardless of the warmer winters induced by climate change (Layne and Bassi, 2008). As shown in Table 6.1, this cultivar is assigned a score of 3 as it provides the highest utility. As a motivator for purchase, this fruit characteristic would appeal to consumers with a biospheric value orientation, that is, individuals who

are concerned about agricultural production's adaptation to climate change and the sustainable management of natural resources. On the other hand, a cultivar with an upright growth habit is better adapted to modern, high-density planting which gives relatively high returns to production (Pieterse, Smith and Lotz, 2006). This trait enables the recouping of money spent on the on-farm climate change adaptation investment. As a motivation for fruit purchase, this attribute serves as an indicator for altruistic value orientation as it appeals to consumers' concern for the viability of farmers' enterprises.

The fruit organoleptic characteristics (fruit size, flesh colour, flesh firmness, skin colour and cultivar harvesting dates) were also assigned ranking criteria that were informed by literature and, in addition, included information acquired from industry experts regarding fruit quality preferences of South Africa's primary export markets (the UK, the Netherlands, the UAE, Saudi Arabia, Hong Kong-China, France, and Germany). These characteristics represented consumer egoistic values as these are the fruit quality indicators used by consumers to determine fruit's ability to meet their consumption needs. Characteristics make the biggest influencers of purchase behaviour. Variable selection was also influenced by data availability.

6.6 Findings

The study used 216 cultivars, which made up between 80% and 99% of the fresh peach and nectarine exports during the 1999 and 2018 period. The study examines cultivar-use over a 20-year turnover period because Savage (1983) and Park and Florkowski (2003) have reported that peach and nectarine cultivars are generally phased out and replaced by superior varieties over a two-decade period. Due to the advanced pace of breeding, competition and fast-changing consumer tastes and values, this turn-over period has been argued to be reduced (Huysamer, 1997).

6.6.1 Mean scores

As shown by the statistics reflected in Table 6.2, South Africa exports during the 1999 - 2018 period provided the highest utility to consumers (on average) through the delivery on egoistic value. As shown by the scores printed in **bold**, the exports showed the highest average scores on the "skin colour" (2.48), "fruit firmness" (2.48) and "fruit size" (2.42) traits. Such high average scores imply that the cultivar selections allowed the industry to be aligned with present and future market opportunities with regard to these three traits. When judging the exports' positioning based on the average scores for "supply period", "chilling requirement", "growth habit" and "fruit shape", which had average scores of 1.83, 2.10, 2.11 and 1.98 respectively, the industry can be said to be merely adapted to current market opportunities and production challenges in South Africa. Therefore, there remains room for improvement.

The statistics show that the industry scored lowest with regard to satisfying the consumer demand for cultivars with a white flesh colour. An average score of 1.66 shows that a significant proportion of exported fruit has yellow flesh. Assuming that the shift in preference to white-fleshed cultivars as opposed to yellow or orange-fleshed cultivars in South Africa's premium markets continues, this result implies that the industry is not well-positioned to achieve premium prices in the future. The country has struggled to respond to the changes in consumer tastes because of the long time required to breed cultivars adapted to the South African harsh production environment. The slow transition in switching flesh colour of export cultivars is cushioned by the sluggish shift in tastes (if any) experienced in some consumer segments (Byrne, 2002), and this allows South Africa to continue to find some demand for its yellow and orange-fleshed cultivars.

Table 6.2: Average quality scores on cultivars used for exports: 1999 - 2018

	Sustainability characteristics		**Organoleptic characteristics**					
	Growth habit	**Chilling Requirement**	**Supply period**	**Fruit size**	**Flesh colour**	**Fruit firmness**	**Fruit shape**	**Skin colour**
Average scores	2,11	2,10	1,83	**2,42**	1,66	**2,48**	1,98	**2,48**
Standard Deviation	0,63	0,72	0,67	0,62	0,89	0,79	0,49	0,65

Source: Authors' calculations

6.6.2 Factor analysis

As shown in Table 6.3, four market strategies can be developed using the cultivar characteristics of the varieties utilised in South African fresh peach and nectarine export market. These were represented by Factor 1 – Factor 4, and they jointly accounted for 62% of the variation in South Africa's fresh export cultivar selections. Factor 1 represented a strategy which capitalised on satisfying consumers' egoistic values as the aesthetic value indicators "fruit firmness" (0.49), "flesh colour" (0.338) and "skin colour" (0.743) had the dominant positive factor loadings. Therefore, this strategy can be described as one that capitalizes on delivering firm-fleshed, red-skinned and white-fleshed fruit. The results show that Factor 1 had a negative loading (-0.603) for the consumer altruistic value indicator (growth habit). This finding shows that "eco-efficiency", as a product value proposition, cannot be achieved in the first strategy, as findings show a trade-off between organoleptic and sustainability traits in the associated cultivars. Factor 2 captured a market strategy whose cultivar selection provided both biospheric and egotistic consumer value. As shown in Table 6.3, there were significant and positive loadings for "chilling requirement" (0.783) and "fruit firmness" (0.340) traits. The overlap between sustainable production and organoleptic characteristics qualifies this as an eco-efficient strategy. The results show that Factor 2 had a negative loading for "flesh colour" (-0.669), implying that consumers in this segment attained the highest utility through the consumption of yellow or orange-fleshed cultivars.

Factor 3 showed congruence in the delivery of egoistic and altruistic consumer values. This is interpreted from the significant and positive factor loadings on the "fruit firmness" (0.463), "fruit shape" (0.697), "supply period" (0.621) and "growth habit" (0.338) traits. This strategy also shows congruency between characteristics that promote sustainable production and consumer satisfaction. As shown, the strategy capitalises on delivering off-peak supply, oblate shape and having firm flesh. Similar to the market strategy represented by Factor 2, the finding shown in Factor 3 shows the existence of a market segment whose market potential is not currently fully exploited by the South African exports, as the altruistic value of the product provided to this strategy is currently not communicated to the consumers. Factor 4 shows a distinct value provision that confined to consumers' egoistic value as this Factor has significant factor loadings for the "fruit firmness" (0.338) and "fruit size" (0.895) cultivar traits only. Therefore, this segment's cultivars were basically large in size and firm-fleshed.

Table 6.3: Factor Analysis results

Value Orientations										
			Biospheric	**Altruistic**	**Egoistic**					
	Eigen Value	Variation explained	Chilling Requirement	Growth habit	Supply period	Fruit shape	Fruit firmness	Fruit size	Flesh colour	Skin colour
Factor 1	1.399	17.489	.150	**-.603**	-.240	.120	**.490**	.057	**.338**	**.743**
Factor 2	1.274	15.929	**.783**	-.046	.085	-.178	**.340**	-.076	**-.669**	-.130
Factor 3	1.172	14.652	.025	**.333**	**.621**	**.697**	**.463**	-.026	.079	.067
Factor 4	1.119	13.991	-.272	.061	.143	-.279	**.338**	**.895**	-.226	.069

Source: Author's calculations

6.6.3 Reliability tests

The sample determinant of 0.738 was acquired from the factor analysis, signifying an adequate extraction of variation per cultivar characteristic. As shown in Table 6.4, the p-value of 0.000 acquired for the Bartlett's test and the 0.5 p-value acquired for the Kaiser-Meyer-Olkin test show a sufficient measure of sampling adequacy and correlation in the matrix of perception indicators to justify the use of a data reduction procedure using factor analysis.

Table 6.4: Results of reliability tests

Test	**p-value**
Kaiser Meyer-Olkin (KMO)	0.5
Bartlett's test	0.000

Source: Author's calculations

5.6.5 Cluster analysis

As shown in Table 6.5, two interpretable clusters were identified using K-means cluster analysis. The first cluster (Cluster 1) was composed of 92 cultivars, and Cluster 2 with 124 cultivars. As shown by p-values, Factor 1 and Factor 2 were the two significant contributors or influencers for determining cluster membership. F statistic of 280.842 for the former versus one of 20.156 shows that Factor 1 has a larger influence than Factor 2. As shown in Table 6.5, Cluster 1 had negative values for Factors 1 and 2, while it had positive values for Factors 3 and 4. However, the F statistic of the ANOVA analysis indicates that Factor 3 did not have a significant influence on cultivar allocation. This implies that Cluster 1 is interpreted to represent a group of cultivars that is used to satisfy the consumer egoistic, and not the consumer altruistic values. In contrast, Cluster 2 had positive values for Factors 1 and 2, while it had negative values for Factors 3 and 4. Therefore, Cluster 2 is interpreted to represent a group of cultivars that is used to satisfy consumer egoistic and biospheric values.

Table 6.5: K-means cluster analysis

	Final cluster centres		ANOVA					
			Cluster		Error		F	Sig
	Cluster 1	Cluster 2	Mean Square	Df	Mean Square	Df		
Factor 1	-.864	**.654**	122.021	1	.434	214	280.842	0.000***
Factor 2	-.336	**.255**	18.507	1	.918	214	20.156	0.000***
Factor 3	**.128**	-.097	2.707	1	.992	214	2.729	1.000
Factor 4	**.137**	-.104	3.068	1	.990	214	3.098	0.800
Number of cultivars	92	124						

Source: Authors' calculations

Note: Variables significant at 10% (; p<0.1); Variables significant at 5% (**; p<0.05); Variables significant at 1% (***; p<0.01)*

Cultivar flesh colour was used to differentiate the strategy 1 and 2 cultivars, as Factors 1 and 2 had distinct differences in this characteristic. Factor 1 cultivars favoured the use of white-flesh colour, while Factor 2 had either yellow or orange flesh. Table 6.6 shows the list of cultivars that serve market strategy 2. These provide eco-efficient value as they promote climate change adapted production, while meeting consumer quality demands.

Table 6.6: Cultivar for eco-efficient market strategy 2

Goudmyn*	Excellence*	Sandvliet*	ARC NE-11	Nectared 9	Super star	April glo	Nectagold
Fairtime	Ambercrest	Crimson Lady	August red	Stark sunglo	Kay Diamond	Royal Glo	Summer diamond
Suncrest	Keisie*	Western Sun*	August bright	Red jewel	Autumn blaze	Zee glo	Candy gold
Sunray*	Spring Princess	Catherina	Early sun grand	Independence	Burnectfour	Rich Lady	Early river
Marina	Floragold	Prof Malherbe*	Fantasia	Unico*	Honey Diva	Summer prince*	Early Dawn*
Transvalia*	Early sun	Woltemade*	Flamekist	Zaigina	Royal Bright	May pearl	Snowhite*
Jim Dandy	Western Cling*	Prof Neethling*	Flavortop	Sunglo *	Diamond Pearl	Burpeachthireteen	Coronet
Novadonna *	Temptation	Elberta	Olympia	Southern glow*	Arctic mist	Rudy sweet	Earlibelle
Hales haven	Sunbright	Turquoise	Diamond zee	Arctic Snow	Boland*	Starcrest	Top Pearl
Nectar*	Sunfire	Emeraude	Honey Kist	Diamond Ray	ARC NE 5*	Earlirich	
Summer glo	Sungrand	Sweet Dream	Honey Blaze	Nectadelicious	ARC NE 9*	Shimmer Pearl	
Summer pearl	August glo	Sweet	Coral Glo	Summer Giant*			

Source: Author's findings
Note: Asterisk (*) marks locally bred cultivars

6.6.4 Discussion

The results from the mean-score analysis show that South Africa's peach and nectarine industry delivers on the consumer value, but prioritises qualities that capitalise on the egoistic values of consumers. The factor analysis revealed four market strategies (represented by Factor 1 - 4) that could be developed from cultivars' qualities. An investigation into the product value propositions in the strategies as indicated by the nature of the relationship between the values represented by the quality indicators was carried out. It showed that the delivery of egoistic value was done at the expense of the altruistic values in the biggest market strategy (Factor 1). However, congruence between egotistic values and biospheric and altruistic values indicators was found in two market strategies (represented by Factor 2 and Factor 3). The high factor loadings for sustainability indicators show that there is market potential for the development of eco-efficient value proposition especially in market segment represented by Factor 2 where biospheric value indicators had the highest loadings. Currently, this segment is reached by emphasising the superior quality in terms of its fruit firmness and potential extra earnings from the possible communication of the sustainability qualities of the cultivars are forgone. As this niche market segment is served by yellow and orange-fleshed cultivars, essentially fruit varieties that are losing popularity, the study's findings point to a new way of reviving demand for these fruit variety types. The value proposition in the market segment represented by Factor 3 mirrors the main export strategy that is used in South Africa as one of the significant Factor's loading is on "off-season supply". As research reports have warned of decreasing premiums in the market across time (DFB, 1994; Ntombela and Moobi, 2013), it would be prudent for the industry to invest in alternative ways of maintaining competitiveness on the market.

The results of cluster analysis revealed that 43% of the existing cultivars could be used in the first two market strategies. However, interpreting the characteristics describing the cultivars in Factor 2 shows that only the yellow and orange-fleshed cultivars in Cluster 1 describe the cultivars that satisfy both the biospheric values and egoistic values of consumers. The identification of these cultivars has provided a starting point for developing ways for exploiting the market potential of the eco-efficient market segment. The remaining 124 cultivars were classified in Cluster 2, which represents the satisfaction of egoistic values. The cultivars scored particularly high in the stated in Factor 4 organoleptic traits but do not address the eco-efficiency niche market identified by Factor 3, as the ANOVA analysis results showed that this Factor did not make a significant contribution to the selection of this group of cultivars. This finding highlights a market opportunity that should be considered in cultivar selection.

6.7 Conclusion

This study sought out to identify markets for strategic attributes in South Africa's peach and nectarine fresh exports. These attributes were defined as those that enable sustainable or responsible consumption as this was deemed an area of possible future growth. The study's findings from the DPDC matrix analysis concur with the empirical literature which states that South African exports held the best position in the European Union when comparing other export destinations. The results demonstrated this as United Kingdom market had all value propositions classified in the DPDC and NPDC quadrants of the DPDC matrix. The United Kingdom was found to have the best positions for the eco-efficient value propositions; particularly biospheric value. This indicates that the marketing of any additional provisions of climate change adaptability has the highest chance of success in this market.

The study's results are significant in that they highlight an avenue of growth that can be achieved by marketing the eco-efficient value in the exports that can be achieved in the declining markets. Thus, they suggest a way of reviving exports. The findings differ past studies which advised that the industry capitalize on the highest growth markets in Asia, but instead warn of the lack of sustainability that would unpin in this growth. It also warns of the further growth potential of this value proposition in the declining market and encourages the marketing of eco-efficient value proposition to encourage sustainable production and consumption.

The results also show that the provision of value proposition 3 also presented growth opportunities for stable markets such as the UK as well as Europe and Russia, Middle East and African markets and risky markets such as Indian Ocean Islands and USA and Canada. This finding shows that expansion into the majority of the market can be facilitated by low-cost production as well as the off-peak supply of fruit. As value proposition 3 captures the strongest elements of the currently implemented export strategy, then the industry should continue with this strategy. As the marketing regions captured in this latent market represent old markets which area declining and new markets, rising markets. A focus on the provision of

aesthetic and eating-quality value should be made in exports made to the Far East and Asian markets. However, the fact that unsustainable provision of good fruit is well-positioned as a cash cow in the largest market is concerning. Although, the study recommends divesting in cultivars promoting such conflicting values, it also recommends that further study be done on how incentives can be structured in order to direct the market towards sustainable consumption.

CHAPTER 7

Manuscript 5: Value-oriented market selection for South African fresh peaches and nectarines

Abstract: *This study sought to identify markets that could promote eco-efficient value in South Africa's fresh peach and nectarine exports. This is done by first using cultivar attributes to determine core value propositions of the industry and then using the dominant product-dominant country matrix to determine the market opportunities of the industry's global markets. The results show that the provisions of eco-efficient value have the potential to revive growth in South Africa's key, dominant, and declining markets and stimulate growth in new markets. The study's findings also show the existence of a resolute market that demands the provision of aesthetic value and eating-quality in the Eastern Hemisphere. While the first finding provide a basis for motivating value-orientated investments, the second shows significant potential for trade to markdown production sustainability. The study provides recommendations on how incentives could be structured in order to direct the market towards sustainable oriented decisions.*

Keywords: product portfolio approach, differentiation strategy, fresh fruit market, green marketing; Global competitiveness

7.1 Introduction

In recent years, sustainability issues have become strategically important to managerial decision-makers as exporting industries face heightened scrutiny from consumers (Chabow-ski et al., 2011). Hence, exporters have been forced to rethink International Market Selection (IMS) and shift from the conventional profit orientation and focus on delivering consumer value through product, market or organizational innovation (To, Chau and Khan, 2020; Salnikova and Grunerta, 2020). The delivery of consumer value has evolved to mean the delivery of hedonic, biospheric and altruistic value, and has been termed consumer eco-efficient value. Simeoni et al., (2020) have noted that ambidextrous strategies which reconcile profitability and sustainability (environmental and social) goals tend to provide a lasting competitive market position. However, research on export strategies that match the evolving definition of consumer value and evolving market requirements have lagged behind in this fast-paced environment of change.

The South African peach and nectarine fresh export sector is an example of such an industry that has implemented a consumer-oriented strategy that delivers on demands for hedonic product qualities. It particularly delivers fruit of good quality traits during the off-peak period when consumers demand is relatively high. Past export analysis research has recommended that the industry implement a profit-orientated, focused strategy which leverages on productivity gains and concentrates on supplying countries with the highest growth in demand. These include Hong Kong, Singapore, Saudi Arabia and Malaysia, which have experienced very high demand growth rates of over 20% since 1995 (BFAP, 2016). The shortcoming of the recommended focused strategy is that it is crafted on the assumption that the

strategic strength or core competency of the industry is defined by the cost-savings capabilities. Using such an indicator assumes that the industry's competitiveness is built around providing low production and yet literature has shown that the industry thrives on capitalizing on superior consumer value provision. The current study argues that core competency of the industry should be measured based on strategic resources, i.e. cultivars and the value proposition that they avail as this can enable the measurement of multifaceted attributes of consumer value. It aims to highlight the different value dimensions of this industry's output and pairs such value to export markets in a bid to uncover latent market opportunities of declining and emerging markets. The study makes this argument by developing indices from cultivar traits expressed in exports to South Africa's regional markets. These indices measure fruit qualities which are sum up into eco-efficient value, consumer demanded qualities and unsustainable provision of fruit. The market positions of the indices measuring eco-efficient value are then used to determine the markets that could be used to implement export ambidextrous strategies.

The core contribution of the current study to agribusiness strategy literature and methodology is that it incorporates sustainability indicators into a core product value calculation that had previously only considered profit-oriented indicators. This analysis' augmentation of including sustainability traits and perceivable traits enables the crafting of an ambidextrous strategy which have been reported to be more useful in setting a foundation for long term success (Simeoni et al., 2020). In addition, the incorporation of product value that is disaggregated into components that promote sustainable production and consumption enables value-orientated investments in market strategy makes valuable contributions to the traditional to profit-driven investments. These are essential factors to capture as the ability to meet these two criteria forms the core of sustainable competitive advantage that will enable growth going into the future. It additionally allows for the highlighting of markets where the country's product have been under-sold as the industry had not marketed environmental friendly and socially astute product features.

The remainder of this paper is structured as follows: Section 6.2 review past studies that have been carried out in this area of research. Section 6.3 describes the methodology, while the next section describes the data used in the study. Sections 6.5 provides the results discusses the findings within the context of the industry. The study is concluded in Sections 6.6 where a few recommendations are also offered.

7.2 Literature review

Identifying the "right" market(s) for expansion is important because it can be a major determinant of success or failure (Papadopoulos and Denis, 1988). Given its importance, IMS attracted significant research attention from the 1960s to the mid-1980s when the world experienced the first wave of growth in firm internationalisation activities (Papadopoulos, Chen and Thomas, 2002). Interest in this area of research waned in the following years. However, this has resurged due to a plethora of opportunities

offered by shifts business environment and technical improvements offered in the 21st century (Matanda, 2012). Knudsen and Madsen (2002) report this research area has also been reinvigorated by the need to find ways of circumventing factors that hinder participation in global markets and access to lucrative markets that is characteristic of the age. Most analyses have been used to explain or predict how firms develop with respect to, among others, the profitability of geographical markets they serve, the changes in the type of entry modes they select, and the competitiveness of the strategy methods they utilize.

Methods for carrying IMS research have relied on economic theories such as Michael Porter's Model for Competitive Advantage (Porter, 1990). The approach defines competitive advantage along the dimensions of strategic scope (the size and composition of the market) and strategic strength (the strength or core competency of the firm) (Shankarmahesh et al. 2016). Hence, IMS as a field of research has simply found ways of measuring these dimensions of strategy and juxtaposed the resulting data to determine the strategic positions business units occupy and determine the markets that would be best suited to offer growth to the current market position.

For the South African horticultural export sector, export strategy analyses have been carried out in order to determine the industry's strategic positioning and opportunities for growth. The current study was conducted with the underlying assumption that cost savings conferred by labour/mechanisation were a critical strategic strength, given the rising cost of labour in the country. The strategic scope for each fruit's export market was measured using the International Trade Centre's (ITC) market attractiveness analysis index, which is constructed from data indicating the relative tariffs, relative distance and the total fruit exports. The study constructed a labour intensity/growth potential matrix and found that nectarines had a stronger market position than peaches (BFAP, 2015). BFAP (2016) further contributed to this field of research by augmenting the ITC's market attractiveness analytical tools by incorporating country demand indicators (GDP growth forecast, seasonality of imports, export volumes growth, and the relative price realisation to the market attractiveness index. This analysis calculated the fresh peach and nectarine and found that the most attractive markets for the sector were Hong Kong, Singapore, Saudi Arabia and Malaysia. The BFAP (2016) contributed to this area of research by providing details of the unique country demand conditions which can limit or promote international trade activities. Further augmentation was provided by Kapuya and Sihlobo (2014) who analysed South Africa's maize export market using of the Strategic Export Market Analysis (SEMA). This study analyses cost implications using five critical elements market access (tariff and non-tariff barriers), market growth (high/low or positive/negative growth), market share (high/low or increasing/decreasing), market competition (farm level and supply chain logistics) and market size (high/low potential or increasing/decreasing size). This profit-oriented strategy determined that the industry was well positioned in Japan, Mexico, Taiwan, United Arab Emirates, Thailand and Zimbabwe.

The weakness of previous studies is that they were designed on the assumption that the strategic strength or core competency of the industry is defined by the cost savings variables (e.g. tariff rates, labour costs, trade agreements). These have followed the argument made by Shankarmahesh et al. (2016) that quotes economic theory's determination of strategic position as being hinged on efficiency. The current study argues that core competency of the industry should be measured based on internal factors and product properties which the firm can control, alter and amend relatively easily and use to improve market positioning. According to Ozturk et al. (2015), the use of product characteristics to measure strategic strength is one of the most used approaches in literature. Several studies have used this approach. For example, a study conducted by Gaston-Breton and Martin (2011) measured the strategic value of a product by its ability to satisfy the values of consumers. This study created an index that segmented Europe in terms of social and personal values and plotted it against the market attractiveness index (constructed from GDP, population, imports, employment expenditure and corruption data). Ozturk (2015) used economic environment and political environment indicators. Other studies that have used product-specific indicators to measure the competitive landscape include Sakarya, Eckman and Hyllegard (2007), Wood, Karriker and Williams (2010), Whitelock and Jobber, 2004; Mellahi, Guermat, Frynas and Al-Bortmani (2003). Others that have used product characteristics to measure customer receptiveness and demand include Sakarya, Eckman and Hyllegard (2007), Cavusgil (1997), Wood, Karriker and Williams (2010), Papadopoulos, Chen and Thomas (2002), Papadopoulos and Martin (2011), Mellahi, Guermat, Frynas and Al-Bortmani (2003) and Matanda (2012).

The current study further argues that the core competency of the industry should be measured on the basis of the qualities of the product. This is an important aspect to include in the analysis of peach and nectarine fresh fruit industry because fruit quality is a critical attribute which determines market access, price levels and market share in this highly differentiated industry. This study defines strategic strength as lying in its strategic resources, i.e. cultivars and the value proposition that they avail in enabling the industry to address the eminent business demands such as climate change adaptability, the satisfaction consumer trait preferences as well as adherence to social requirements such as fair remuneration. This approach of considering the quality of innovation has been mainly used in innovation intense industrial goods sectors such as chemicals and pharmaceutical industries that have been known to have value in their technology portfolios. One example of such a study was conducted by Fabry, Ernest, Langholz, and Koster (2006) using quality of product patent as a strategic strength. A quality construct was developed from the technology's impact and was measured based on the rate of patents granted, the international scope of patent applications and the patent citation ratio. Ernest and Omlad (2011) combine 'portfolio size' (the number of active patents), 'market coverage' (the extent of patent protection in global markets) and 'technology relevance' (number of patent citations) to construct the 'Patent Asset Index' as a new key metric. The study's findings showed that product innovation approach provided better information on a firm's strategic position in a market as compared to comparable profit-oriented analysis. A similar study

conducted by Ayal et al., (1987) was also done to evaluate US marketplace opportunities for chemical products from other countries. Ayal et al. (1987) calculated the strategic position using market attractiveness index (constructed using the annual growth rate, market size, demand stability, competitive concentration, technical risk, skill ratio, capital intensity, percentage sales indicators) and competitiveness index (constructed using value of exports, distribution network export profitability, technological advantage, product quality, production capacity, organization relationships, export sales requirements indicators).

The current study argues that the strategic strength of horticultural industries which are diversified using technologies such as cultivar should be analysed using a technology portfolio approach. This allows literature to infer linkages between export strategies and environmental consequences factors. The derivation of such linkages allows the current study to contribute to the conversation about growing concerns on the negative relationship between increased export activity and adaptation to changing environment (Leonidas, Katsikeas, Fotiadis, and Christodoulides, 2013). According to Zeriti, Robson, Spyropoulou (2014), such an avenue of inquiry has yet to be fully explored and research providing such information remains scanty. According to Leonidas, Katsikeas, Fotiadis, and Christodoulides (2013), there is a need for research on international green marketing strategy. Specifically, there is a need to investigate ways of structuring strategic thinking to address globalization trends, environmental concerns and customer value enhancement. Due to this indicator's ability to capture both consumer-orientated and sustainability-oriented values, the study could make contributions to ambidextrous and value-based strategies which promoting the research global goals of fighting climate change impacts and promoting responsible consumption.

7.3 Research methodology

7.3.1 Research method

The paper performs export portfolio analysis utilizing the Dominant Product–Dominant Country framework (DPDC). This framework is arrayed along two axes to select specific product sectors and target markets for export promotion (Shankarmahesh et al., 2005). It performs IMS by determining the intersection between a country's internal strengths and competencies, as reflected in its export performance and attributed to product sector characteristics (Shankarmahesh et al., 2006). Specified product groups are paired with export destinations using statistically determined values and/or subjective determined cut-off points. The pairing results in a 2x2 matrix with the following four categories; non-dominant product–non-dominant country (NPNC), dominant product–non-dominant country (DPNC), non-dominant product–dominant country (NPDC) and dominant product–dominant country (DPDC). This research uses spatial segmentation based on geography to segment export market instead of country boundaries in order to enable the generalization of findings on markets that easily be reached. It follows

the argument made by Hofstede, and Wedel, and Steenkamp (2002) who demonstrated the insightfulness of that market characterization and segmentation across international borders. The framework is further augmented by considering the measuring the value proposition of a single product on the x-axis instead of comparing the product characteristics of various products. The augmented matrix is illustrated in Table 7.1 below.

Table 7.1: Adapted dominant product-dominant country matrix

	100%			
Market share of export region in global market	High	Non-dominant product value / Dominant in export region	Dominant product value / Dominant in export region	
	Low	Non-Dominant product value / Non-Dominant in export region	Dominant product value / Non-Dominant in export region	100%
	0%	Low	High	
		Market share of product value index in regional markets		

Source: Adapted from Shankarmahesh et al. 2005.

Adaptations of the DPDC framework in this study allows for better applications of Porter's Model for Competitive Advantage (Porter, 1990), which summarizes successful IMS as the intersection of dimensions of an industry's strategic scope (industry's prospects measured using macro-economic market estimation data) and strategic strength (core competency of the industry). Similar to previous used indicators, the model's indicator fall within the description of the measurement indicators (wealth, size, growth, competition and ease of access) which have been reported by Sakarya et al., (2006) as being used in the past.

In the current study, the strategic scope was determined using the percentage market share on the destination segment in the global market. A subjectively determined measure of growth as determined by Kapuya and Sihlobo (2014) was used to decipher between dominant and non-dominant market share. The strategic strength of South Africa's peach and nectarine industry as being inherent in the cultivars that are used for export. These deliver the fruit qualities that add to consumer value. This was measured using composite indices generated from the factor analysis conducted in paper 4 that were constructed from the cultivar characteristics of the varieties used for export. Aggregate time series composite indices were constructed all value propositions in all regions. This was weighted on the percentage of use of each cultivar in each market per year of export. A subjectively determined cut-off point for dominant and non-

dominant product was determined following the example set by Hambrink, MacMillian and Day (1983) and Shankarmahesh et al. (2006).

7.3.2 Data

In the current study, the strategic scope of the South Africa fresh peach and nectarine sector was defined as the size of the market share of South African exports in a marketing region for the global market. This market-share size was classified as either having a high (dominant) or low (non-dominant) market share. A high share of the regional market is defined as one that held an average market percentage that was higher the average percentage market share of South Africa's export in the rest of the world during 2005 – 2018 period. Data on real global export earnings was used for this calculation and it were acquired from the ITC's data repository (www.trademap.org). The regional market classification was adopted from the producer organization for fresh deciduous fruit in South Africa, HORTGRO, which report cultivar used according to seven markets: the United Kingdom, Europe and Russia, the Middle East, the Indian Ocean Islands, the Far East and Asia, USA and Canada and Africa.

The sector's strategic strength was measured using the average increase in regional demand for the different value propositions offered by South Africa's exports. Four value propositions measured the clusters of cultivars that were exported to the different regions as described in Manuscript 6. A market growth rate of 10% was used as a point of distinction between dominant and non-dominant product value classification. According to Hambrink, MacMillian and Day (1983), this is the cut-off point that is recommended by for product portfolio analysis. As done by BFAP (2016), a cut-off point of 20% is used to distinguish high growth from very high growth. This cut-off point was used during the discussion of the results. Unlike previous studies that used the growth indicators of a single year for this analysis, this study used the average year-on-year growth for the period under study. This was done in order to improve the analytical method's limitation of not providing short term insights, as stated by Kotler and Armstong (2016).

7.4 Results

7.4.1 Descriptive results

7.4.1.1 Quality descriptions

A total of 217 cultivars were used for exports during the 2005 - 2018 period. As shown in Table 7.2 below, the largest proportion of these cultivars was used to meet the demand in the United Kingdom. The lowest number was utilised in the USA and Canada markets. As shown by the summary of the attribute descriptions given in the table, three characteristics: "fruit size", "flesh firmness" and "skin colour" ranked highest in all markets. This means that exports were generally large, red-skinned and had a

relatively long shelf-life. “Skin colour” was found to be a very important attribute for export as it had the highest ranking for all regions except for the Indian Ocean Island, and the USA and Canada regions. The highest scores for climate change adaptability was found amongst the USA and Canada exports while the highest score for farm productivity was found in the exports to Africa. This means the USA and Canada market had cultivar cluster, which was better adapted to climate change than other regions while Africa’s selections had lower costs implications.

Table 7.2: Average quality scores on cultivars used for exports during 2005 – 2018

	Number of cultivars	Harvest period	Chilling requirement	Growth habit	Fruit size	Flesh colour	Flesh firmness	Fruit shape	Skin colour
UK	207	1.84	2.07	2.12	**2.46**	1.75	**2.47**	2.01	**2.55**
Europe and Russia	171	1.83	2.08	2.12	**2.51**	1.65	**2.52**	2.00	**2.55**
Middle East	192	1.84	2.09	2.13	**2.45**	1.65	**2.46**	2.02	**2.51**
Indian Ocean Island	120	1.88	2.12	2.13	**2.47**	1.59	**2.55**	2.02	**2.50**
Far East and Asia	98	1.78	2.02	2.11	**2.59**	1.86	**2.63**	2.06	**2.70**
USA and Canada	41	2.03	2.23	2.08	**2.63**	1.70	**2.78**	2.10	**2.40**
Africa	155	1.86	2.05	2.14	**2.46**	1.71	**2.48**	2.01	**2.49**

Note: Figures written in bold font show values with the highest quality value per market segment
Source: Author’s findings, 2020.

7.4.1.2 Value proposition trends in marketing regions

The results of the factor analysis determined that the industry had four core value propositions. Value proposition 1 was found to generally take small negative values of -0.25 to 0 across all regions. This trend means that although there was a trade-off being aesthetic cultivar traits and sustainable production across time, this was minimal. The Far East and Asia market was the only market that recorded high values such as 0.6 on this index. Value proposition 2 was found to follow decline paths in all markets. This result implies that there was general decline in climate change adaptability in the cultivars used in all regions over time. The markets showed decreases of between 0.9 (the USA and Canada) and 0.1 (Africa). Value proposition 3 had positive values and followed a general increasing trend. This trend means that the enterprises were more efficient in production during the period covered in this study. The highest values for this index were recorded in the USA and Canada market. Value proposition 4 showed the least changes during the period under study. This means there were very few improvements in aesthetic cultivar traits in all the market. The index’s values fluctuated between -0.1 and 0.2 save for the Far East and Asia market which recorded a high value of 0.8 in 2010.

6.5.1.3 Growth analysis descriptions

The study found that South Africa's average share of the global market for the period 2005 – 2018 was 1.9%. This market share value is quite low considering that other fresh stone fruit exports such as apricots and plums had a growth rate of 2.4 and 15% respectively (ITC, 2020). The low growth rate is attributed to the steep competition for shelf-space with other fruits which outperform peaches and nectarines due to their longer shelf-life, convenience, sweeter tastes and multi-utility (BFAP, 2019).

7.4.2 Empirical results

7.4.2.1 Market share analysis results

Table 7.3 below shows the average market shares for South Africa's geographical markets.

Table 7.3: Average shares for South Africa's geographical markets

	United Kingdom	**Europe and Russia**	**Middle East**	**Indian Ocean Islands**	**Far East and Asia**	**USA and Canada**	**Africa**
Region's share in SA's exports	45.6*	19.8*	24.4*	0.4	1.5	0.5	7.8*
SA's share in world trade	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Category	High	High	High	Low	Low	Low	High

Note: Asterisks mark the market share figures that are higher than South Africa's share of world trade
Source: Author's findings, 2020.

As shown, four regions were classified as high share markets. These were the United Kingdom, Europe and Russia, Middle East and Africa. Within the Europe and Russia market, the Netherlands took up the majority (over 85% in 2018) of the export volumes. The significantly higher proportion of this country's imports are probably due to the colonial history that exists between the two trading countries. Other significant markets in the region included Russia, France, Germany and Belgium. The largest markets in the Middle East region is the United Arab Emirates, which took up the majority (over 95% in 2018) of the exports volumes. Other significant market in the region include Saudi Arabia, Kuwait and Bahrain. Most of the exports in Africa were destined for Botswana (30% in 2017), albeit these exports started in 2010. The ITC data shows that the countries that have consistent exports since 2001 are Mauritius, Zambia, Zimbabwe, Angola and Mozambique.

The three regions that were classified as low share markets were the Indian Ocean Islands, Far East and Asia and the USA and Canada markets. This result means South Africa has a weak market presence in these regions. The Indian Ocean Island market, in particular, did not have islands or countries that consistently imported fruit from South Africa. Apart from Australia, the islands and countries imported peaches and nectarines for about two or three years in succession. The highest exports in the Far East and

Asian market went to Hong Kong (China), Malaysia and Singapore. These three countries took up 90% of the regional market's exports.

7.4.2.2 Growth analysis results

Table 7.4 below shows the results for the average growth in the demand for the four value propositions provided by South Africa to its seven regional marks. As indicated in the table, the exports made between 2005 and 2018 showed an increase in demand for value propositions 2 and 3. This means the cultivars selected all regions significantly promoted the provision of sustainable consumption. Using 20% as the as a point of distinction between high and very high growth, the results show that the Middle East, Europe and Russia regions have value propositions 2 and 3 both showing very high growth. The United Kingdom showed very high growth in demand for value proposition 2 while Indian Ocean Island, African, USA and Canada regions showed very high growth statistics for value proposition 3. Different from the other global markets, the Far East and Asian market showed growth in demand for value propositions 1 and 4. Very high growth in demand was found for value proposition 4 which signified had no negative implications for sustainable production. The United Kingdom market showed growth in value proposition 4. Negative growth was noted for value proposition 1 was noted in four regions (Middle East, Indian Ocean Islands, USA and Canada, and Africa) while no significant growth was recorded for the United Kingdom, and the Europe and Russia market.

Table 7.4: Growth share of market regions

	Value proposition 1	Value proposition 2	Value proposition 3	Value proposition 4
United Kingdom	0.07	**0.28***	**0.18**	**0.13**
Europe and Russia	0.02	**0.40***	**0.27***	0.08
Middle East region	-0.27	**0.26***	**0.27***	0.06
Indian Ocean Island	-0.25	**0.17**	**0.32***	0.02
Far East and Asia	**0.19**	**0.10**	**0.13**	**0.27***
USA and Canada	-0.02	**0.18**	**0.31***	0.00
Africa	-0.11	**0.15**	**0.21***	0.02

Source: Author's findings, 2020.
Note: Values that are written in bold text signify proposition with a high growth potential per market region.
Note: Bold values with an asterisk signify proposition with a very high growth potential per market region.
Note: VP 1 = egoistic value was done at the expense of the altruistic values
VP 2 = biospheric value; VP 3 = Altruistic value; VP 4 = Egoistic value

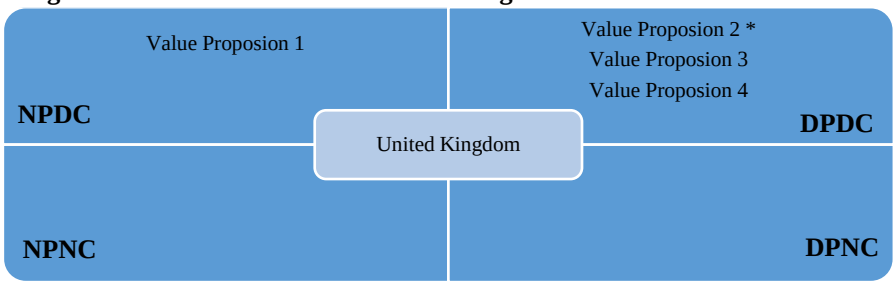
Assuming the demand calculated trends continue, the results imply that an improvement in the delivery of an eco-efficient value proposition is likely to increase exports in all markets. The provision off-peak supply and altruistic value was found to be associated with higher growth figures than the provision of biospheric value. An increase in aesthetic and eating-quality is likely to result in positive response in the United Kingdom, the Far East and Asian markets. Unsustainable provision of consumer demands

attributes was associated with a decrease in most markets. This result makes a case for the reduction of such practices as they were found to reduce economic rewards.

7.4.3 Dominant product-Dominant country analysis

Figure 7.1 below shows the DPDC matrix for the United Kingdom market. As shown, the markets for three of the four value propositions to were classified as DPDC. This finding means that South African export provision of these three propositions is associated with the industry occupying the best possible position in this market. However, the provision of value proposition 1 is associated with a stable position (low growth but high share) in market. This value proposition in classified in the NPDC quadrant, which is described as a cash cow market for South Africa in the United Kingdom. The matrix results can be interpreted to imply that growth in exports can be achieved by maximizing on the provision of biospheric value as it has a very high growth rate. The provision of off-peak supply, altruistic value and good quality fruit is likely to also provide growth but this could slow down. However, this will not threaten the industry's performance in this market as it will hold cash cow position. According to Shankarmahesh et al. (2006), product positioning such a market is perfect for innovative growth. Hence, private and public sector efforts should be made to expand such positions. In the event that market maturity is reached, new product life should be generated by finding new users and modifying the product (Shankarmahesh et al., 2006). The unsustainable provision of quality fruit (Value proposition 1), on the other hand, is classified as a cash cow. As this threatens the provision of strategic attributes associated sustainable production, South Africa should divest in these cultivars filling this value proposition and capitalize on the rising stars (value products 2 - 4).

Figure 7.1: Market growth-share matrix for the United Kingdom market.



Source: Author's findings, 2020.
Note: Asterisks marks proposition with a very high growth.
Note: NPNC = Non-dominant Product–Non-dominant Country; DPNC = Dominant Product–Non-dominant Country
NPDC = Non-dominant Product–Dominant Country; DPDC = Dominant Product–Dominant Country
Note: VP 1 = egoistic value was done at the expense of the altruistic values
VP 2 = biospheric value; VP 3 = Altruistic value; VP 4 = Egoistic value

Figure 7.2 below shows the DPDC matrix for the Europe and Russia, Middle East and African markets. Analyses for the three regions were done separately however, the results of the analyses yielded the

similar matrices hence their representation on a single matrix. As shown, the provisions of value propositions 2 and 3 which indicate the sustainable consumption is associated the exports occupying the best positions in these markets. These were classified in the DPDC quadrant. The statistics on the growth analysis showed that there is more potential growth in the provision of biospheric value in the Europe and Russia market and higher growth prospects lay in the provision of off-peak supply and altruistic value in the African and Middle East markets. As indicated in Table 6.5, the provision of proposition 2 was not as promising as the aforementioned regions, so this proposition may be classified as a cash cow if growth slows down with time. Hence, caution should be exercised in making investment decision given this possibility. Value proposition 1 and 4 were classified as cash cows. Given that sustainable production is a strategic attribute in the 21st century, South Africa would probably like to increase investment in development of cultivar that promote the provision of value position 4 and divest in the clusters for proposition 1. Efforts from both the private and public sectors should be geared towards developing strong linked in the value (e.g. through consortia) in order to fully utilise the market opportunity (Shankarmahesh et al. (2006). This is particularly true for value proposition 4.

Figure 7.2: Market growth-share matrix for the Europe and Russia, Middle East and African markets.

Source: Author's findings, 2020.

Note: NPNC = Non-dominant Product–Non-dominant Country; DPNC = Dominant Product–Non-dominant Country
NPDC = Non-dominant Product–Dominant Country; DPDC = Dominant Product–Dominant Country

Note: VP 1 = egoistic value was done at the expense of the altruistic values
VP 2 = biospheric value; VP 3 = Altruistic value; VP 4 = Egoistic value

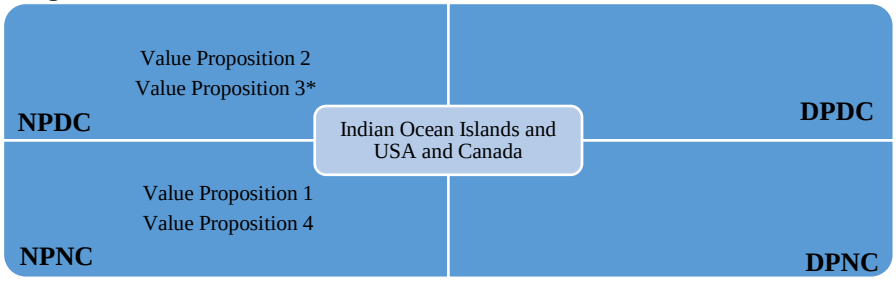
Figure 7.3 below shows the DPDC matrix for the Far East and Asian market**.** All four value propositions were classified in the DPNC quadrant. Value position 4 shows very high growth, whereas the remaining three show growth that are below 20%. Hence, South Africa should invest in using cultivars of the highest aesthetic quality as the results shows that this where growth in revenue lies in this market. Investment into value provision should be considered with caution. Shankarmahesh et al., (2006) recommend that efforts should be channelled towards examine the presence of any structural impediments to the export success. An example could be tariff structure and international trade agreements. The stiff and formidable competition waged by other Southern Hemisphere exporters that have low-cost advantage due to their closer to these markets (Australia) and or have preference agreements (Chile) should encourage the industry to proceed cautiously.

Figure 7.3: Market growth-share matrix for the Far East and Asian markets

Source: Author's findings, 2020.
Note: Asterisks marks proposition with a very high growth
Note: NPNC = Non-dominant Product–Non-dominant Country; DPNC = Dominant Product–Non-dominant Country
NPDC = Non-dominant Product–Dominant Country; DPDC = Dominant Product–Dominant Country
Note: VP 1 = egoistic value was done at the expense of the altruistic values
VP 2 = biospheric value; VP 3 = Altruistic value; VP 4 = Egoistic value

Figure 7.4 below shows the DPDC matrix for the Indian Ocean Islands, and USA and Canada markets. As shown value propositions 1 and 4 are classified in the NPNC quadrant. This result implies that South Africa does not fair competitively in these markets when competing on aesthetic and eating-quality perspective. Therefore, the industry should focus on the provision of eco-efficient value in their product. In particular, the provision of off-peak supply of fruit and altruistic value as value proposition 3 recorded very high growth statistics. As value proposition 3 captures the strongest elements of the export strategy that has been applied by the country, then the industry should not struggle with investing in this focused strategy. However, precaution should be taken as these are low share markets may not reward such investments with profits.

Figure 7.4: Market growth-share matrix for the Indian Ocean Islands, USA and Canadian markets



Source: Author's findings, 2020.
Note: Asterisks marks proposition with a very high growth.
Note: NPNC = Non-dominant Product–Non-dominant Country; DPNC = Dominant Product–Non-dominant Country
NPDC = Non-dominant Product–Dominant Country; DPDC = Dominant Product–Dominant Country
Note: VP 1 = egoistic value was done at the expense of the altruistic values
VP 2 = biospheric value; VP 3 = Altruistic value; VP 4 = Egoistic value

7.5 Conclusion and recommendations

This study sought out to identify markets for strategic attributes in South Africa's peach and nectarine fresh exports. These attributes were defined as those that enable sustainable or responsible consumption

as this was deemed an area of possible future growth. The study's findings from the DPDC matrix analysis concur with the empirical literature which states that South African exports held the best position in the European Union when comparing other export destinations. The results demonstrated this as United Kingdom market had all value propositions classified in the DPDC and NPDC quadrants of the DPDC matrix. The United Kingdom was found to have the best positions for the eco-efficient value propositions; particularly biospheric value. This indicates that the marketing of any additional provisions of climate change adaptability has the highest chance of success in this market.

The study's results are significant in that they highlight an avenue of growth that can be achieved by marketing the eco-efficient value in the exports that can be achieved in the declining markets. Thus, they suggest a way of reviving exports. The findings differ from past studies which advised that the industry capitalize on the highest growth markets in Asia, but instead warn of the lack of sustainability that would unpin in this growth. It also warns of the further growth potential of this value proposition in the declining market and encourages the marketing of eco-efficient value proposition to encourage sustainable production and consumption.

The results also show that the provision of value proposition 3 also presented growth opportunities for stable markets such as the UK as well as Europe and Russia, Middle East and African markets and risky markets such as Indian Ocean Islands and USA and Canada. This finding shows that expansion into the majority of the market can be facilitated by low-cost production as well as the off-peak supply of fruit. As value proposition 3 captures the strongest elements of the currently implemented export strategy, then the industry should continue with this strategy. As the marketing regions captured in this latent market represent old markets which area declining and new markets, rising markets. A focus on the provision of aesthetic and eating-quality value should be made in exports made to the Far East and Asian markets. However, the fact that unsustainable provision of good fruit is well-positioned as a cash cow in the largest market is concerning. Although, the study recommends divesting in cultivars promoting such conflicting values, it also recommends that further study be done on how incentives can be structured in order to direct the market towards sustainable consumption.

CHAPTER 8

8.1 Summary and conclusion

The peach and nectarine fresh fruit sector has experienced changes in cultivar use due to environmental pressures caused by climate change, and consumption patterns resulting from consumer value-orientation demand shifts. Producers and exporters have been compelled to adjust their cultivar selections in order to meet these changes in consumer expectations and production demands. Such changes have been gradual and enduring therefore warranting an investigation into the myriad of unanswered questions regarding the effects of these global changes on both technology and food markets. Examples of such questions that are answered in this thesis are:

- Is there a trade-off between cultivar characteristics which promote sustainable production and non-environmental characteristics in the cultivars used for South Africa's peach and nectarine industry's fresh fruit exports?
- What are the long term trends in the industry's climate change adaptive capacity or eco-efficient value provision?
- Could the increase in international earnings experienced in fresh peaches and nectarines be attributed to higher climate change adaptability?
- Which cultivars could be used to market the additional value that provide climate change adaptability?
- Which markets could be targeted in expanding the provision on eco-efficient value proposition?

This thesis is presented in the form of five manuscripts that strove to answer these research questions and the principal focus in each of them is summarized as follows:

Manuscript 1 answers the first research question by performing a trend analysis on eight genetic attributes in the cultivars that were used between 1956 and 2015. The paper used national and international cultivar registries to access the cultivar description and ranked qualities of the selected cultivar attributes using a three-point Likert scale. The ranking was done according to the cultivar trait's ability to meet the industry's changing production and consumer demands. The results of the analysis show a general improvement in quality for both the production and the perceivable (organoleptic) cultivar characteristics. There was a slight trade-off between these two type cultivar characteristics, which particular resulted in low expressions of characteristics that promoted farmers' welfare.

Manuscript 2 answers Research Question 2 by constructing indicators that measure the long-run trends in product value associated with the industry's fresh fruit exports. Principal component analysis is used to

extract and summarize the product value propositions identified in composite indices that were constructed by weighting the proportional use of cultivars in exports between 1956 and 2017. The indices acquired from the analysis were found to measure the provisions for sustainable consumption, good-quality fruit and off-peak fruit supply. The study's results show that progress was found in the provisions for sustainable consumption and this was mainly driven by improvements in cultivars' climate change adaptability. However, the last two decades of the period under study have seen successive lower readings on this index. Improvements in fruit quality index were found to be attained at the expense of farm enterprise productivity. The study concludes that strategies be developed to encourage the use of cultivars that promote responsible consumption as, if left uninfluenced, market forces will spur unsustainable production.

Research question 3 was answered in Manuscript 3, which evaluated the role of a product's value propositions in influencing international trade. This investigation is done using the gravity model and incorporated product quality characteristics, tariffs, and demographic, demand and economic indicators. It used panel data from South Africa and 21 trading partners for the period 2001 and 2017. The study's results showed that the delivery of products with off-season and aesthetic value proposition did not lead to a significant increase in export earnings. On the other hand, improvements in eco-efficiency in products were associated with lower export earnings. The study shows that the industry is experiencing a negative end-game relative to climate change adaptation. It recommends that efforts be directed towards finding ways of stimulating responsible consumption in order to make the provisions of eco-efficient value pay-off.

Research question 4 was answered in Manuscript 4 which segmented the international market according to the strategies that can be used for exports as determined by product value attributes. This was done by conducting multivariate analysis on production and sensory characteristics of peach and nectarine cultivars that were used for South Africa's fresh exports in between 1999 and 2018. The results of the analysis showed that the sector provided cultivars to, four market segments in the main. Two of these segments are described as having an eco-efficient value proposition and promoted responsible consumption. The study identified 64 cultivars that are used in one of these segments. The study recommends the development of an eco-label for climate-smart cultivars as this would enable producers to communicate the value provided by the cultivars meeting the criteria of this label. Creation of this label could also provide an avenue towards attaining higher returns to the additional value provision.

Lastly, Manuscript 5 aimed at presenting international market criteria that can assist in driving export decisions that promote the achievement of consumer values. This study makes a contribution to international market selection studies by conducting this market with consumer value that is dissolved into biospheric, altruistic and hedonic value. The study used the dominant product-dominant country approach to match product value propositions to South Africa's fresh peach and nectarine industry's

international markets. The core value propositions were determined indices derived from factor analysis performed on cultivar characteristics of fruit varieties that were used for export between 2001 and 2018. Secondary data on percentage use of each cultivar in each of the seven identify export regions were used to weight the indices. The study's results show that latent markets for eco-efficient exist in South Africa's oldest, dominant, wealthiest countries which happen to be declining such as the United Kingdom and the European markets. A demand for eco-efficient value was also found in the newer and fast-growing markets, such as the Middle East and Africa. The results also show a resolute market for unsustainable production in the same markets as well as in Asia.

8.2 Theoretical contributions

This thesis made contributions to consumer and international trade literature by way of providing new data, methodical approaches and empirical evidence. These contributions are detailed in each manuscript and summarised as follows:

Manuscript 1 provides a novel account of the quality changes of cultivars used for exports. Thus, it availed data that was not available before to previous global studies which had monitored technology markets. These global studies have given an account of the funding patterns, selection and turnover of cultivars and other genetic material, adoption rates shifts in the geographical distribution of modern varieties, the type of intellectual property rights utilised, and changes in the types of breeding techniques used (Byrne, 2005; Fideghelli et al., 1998). Studies on South African peaches and nectarines have particularly documented on the history of the country's federal cultivar development programme, changes in key breeding priorities, the evolution of breeding methods, cultivar use patterns and cultivar concentration measures (Pieterse, Smith and Lotz, 2012; Pieterse, Cook and Theron, 2006; Pieterse, 2013), however analysis of the trends in quality have not been documented. This contribution to literature also determined the type of characteristics that are currently proliferated and compares the dominance of characteristics that promote sustainable production to the characteristics which provide aesthetic value and promote consumers' eating quality. This is important information as this industry is demand-driven and it answers the question, "Is the pursuit of meeting consumers demand at the expense of our environment and the welfare of farmers?" The paper's findings contribute to the ethical debate about fair value and sustainable exports.

Manuscript 2 makes an empirical contribution to literature as it provided an alternative way of measuring eco-efficient value or sustainable consumption. Previous studies have used various methods to construct an index that measures this phenomenon but, according to Moyer and Hedden (2020), these were not sufficiently sensitive to measure behavioural changes and are thus inadequate to advocate for continued improvements. As a result, available indicators could not capture the consumers' contribution to the fight against climate change that has resulted from the incentives provided towards this cause. Therefore, the

aspects of shared responsibility in driving responsible consumption were not captured. Consequently, changes in the values of such indices were limited in their ability to motivate for increases in sustainable consumption as the underlying data was not directly linked to consumer behaviour but associated with the actions of public administrative authorities. Alternative studies have focused on small segments of the market and were confined to analysing goods with specialised food eco-labels. Due to this missing characteristic, the available indicators did not sufficiently measure behavioural changes and were thus inadequate to advocate for continued improvements that are important for long-term climate change adaptation. The research also fills a critical need for new indices for measuring Sustainable Development Goal 12, which has been reported as having the largest number of indicators (10 out of 13) that are not measurable (tier III indicators) (Adams and Judd, 2018).

Manuscript 3 made an empirical contribution to international trade literature as it provided a different way of measuring product quality. Most studies have previously incorporated product quality in the gravity model, however, these had largely been measured using proxies of various forms of product prices (Crozet *et al*. 2012; Dal Blanco *et al*., 2015; Kapuya, 2015; Curzi *et al*., 2015). The use of "price" as a proxy for measuring quality is often problematic because it holds the assumption that an increased quality is associated with an increase in price, hence, it introduces some bias in the model and studies that have used this approach have often encountered the endogeneity problem as prices often capture other product characteristics unrelated to quality (Curzi *et al*., 2015). Previous international trade studies (such as Dal Bianco *et al*., 2015) have also shown that quality improvement in products has almost always had a negative effect on trade and this is not always the case in market observations. Therefore, disentangling the different aspects of quality was very revealing as this study showed that it is the quality improvement that was not communicated or factored into the marketed product value (i.e. eco-efficient value) that has a negative association with export earnings.

Manuscript 4 contributed to preference analysis in empirical findings by including production indicators to an analytical approach that had only been carried using fruit quality attributes that were perceivable to the consumers. By so doing, the study brings in the dimension of implicit consumer demand into the current literature that has been confined to investigating the explicit demand for perceived product characteristics. Examples of these studies in the global peach and nectarine industry are Crisosto, Crisosto, Echeverria and Puy (2006), and Cirilli et al., (2016), which have carried out the same analysis but confined to using only sensory characteristics. Past studies have only used primary data for preference analysis and these studies were subject to bias due to the individual-biases on the interviewed consumer and the fruit biases (it is not always possible to get at the same level of fruit ripeness at the time of the survey). The use of recall methods have been also plagued with numerous limitations. Therefore the use of secondary data to this type of analysis is a contribution that overcomes this limitation. Lastly, the study

provided a novel list of cultivars that could be potentially used to acquire higher earnings from additional eco-efficient value provision.

Lastly, Manuscript 5 makes a contribution to export market analysis of South Africa's peach and nectarine fresh exports using quality measures which were specific to each export market. It is an addition to other global studies such as Fabry, Ernest, Langholz, and Koster. (2006), Leonidas et al. (2013) and Didenkoa Kunzeb, and Skripnukc. (2015) that have analysed the strategic positioning of products in technology market. Previous studies (BFAP, 2016; BFAP, 2017), had captured the strategic strength of the industry using input-intensity, seasonality of imports, tariff measures and policy environment. The alternative use of this proxy for measuring an industry's core competency is valuable because quality plays a central role in this highly differentiated fresh fruit industry as it forms a critical determining of competitiveness and continued market participation. The incorporation of eco-efficient value in this analysis enables the determination of value-orientated strategies as opposed to past studies that determined profit-oriented strategies. This is important as it enables value-orientated investments in market strategy as opposed to the traditional to profit-driven investments.

8.3 Implications of research findings

This research was premised on Resources Based View, Ricardian theory of international trade, Linder's hypothesis and Porter's theory of competition, which predicted that an increase in the use of assets that provide an increase in eco-efficient value would lead to better market performance. However, the industry under study showed mixed results with regard to steering the course of this prediction. In line with the prediction, a comparison between long-term product value and short-run value, reveals an increase in environmentalism displayed in the industry's cultivar selection over time. This implies that the technology market is functioning efficiently and the food market is able to adjust to the needs of the consumers and producers within the limits of the genetic resources available. Therefore, this outcome does not imply the need for any interventions by the public sector, international property rights governing bodies, civil societies or private sector.

However, the departure from the theoretical prediction by the international trade market reveals some market inefficiencies. The findings show that provision of eco-efficient value has experienced lower demand (Manuscript 2) and has reduced trade earnings (Manuscript 3) unlike what is expected. This was attributed to the information asymmetry between the technology market and the retail market, where the consumers, who drive the latter, are unaware of the implied meaning of their demands for perceivable cultivar characteristics. These findings imply that consumers are restricted in their ability to express their environmentalism due the limitations in access to information on the implications of their purchase

decisions. Therefore, the study highlights the need to fill this gap in order to correct the market functioning and possibly stimulate responsible consumption.

The study findings highlight the need to find ways to price-in environmental qualities of products into the overall product price-tag. This is firstly due to the existence of trade-off between sustainable production characteristics and organoleptic characteristics. Secondly, this is due to the lack of significant increase in export returns attributed to the provision of eco-efficient value. Lastly, due to the large potential for profitable trade using unsustainable cultivar selections. As shown by the results, if the markets are left unchecked, they are likely to promote unsustainable production and consumption.

8.4 Recommendations

The thesis makes the following recommendations:

- The study recommends that better communication of the superior export product's eco-efficient value propositions be utilized to increase market growth in the two-thirds of the market where it provided competitive positioning. This should be particularly applied the US and Canada market where consumers have a preference for the cultivar varieties which rank high in the provision of this product value. In addition, the product's ability to meet high-quality demands should be used as the main selling point demands in the Far East and Asian markets.
- Collaborative efforts from the private and public sector should be formulated to provide resources and policy instruments to enable the development of this niche markets.
- Similar studies should be conducted for other fresh fruit industries in order to explore areas of collaborative marketing solutions

- Future studies should be undertaken on ways of calculating the provision of eco-efficient value so that agricultural industry can develop ways of encourage sustainable production and consumption. A market solution that promotes responsible consumption will ensure commitment by industry role-players in the whole value chain.

8.5 Study's limitations

The study's analyses is not exempt from potential improvements. Firstly, other characteristics such as fruit sugar and acid content which make a very big contribution to consumer value can be included to the analysis. This can be applied to future studies that focus on the cultivars that are currently in use entailing,

broader and in-depth descriptions. Another limitation was that not all cultivars were used in the analysis because the exports data only provides the names of cultivars that contributed more than 1% of annual exports. Although, the sample was deemed to be representative, future studies could use shorter time series (1996 up to date) that have a more detailed breakdown of the data. The data and results can only be used to make inferences to other Southern Hemisphere producers that share the same definitions of quality. Areas in the Northern Hemisphere may experience warmer winters in future due to climate change, but would not support the use of low chilling unit cultivars. Therefore a re-ordering of the Likert scale is of the essence. Due to the long time period covered, the study was restricted in the type of Likert scale that it can use. Future studies could make break this limitation provided they obtain access to better data. Despite these weaknesses, the study is of value as it made novel and foundational contributions to literature on which the suggested improvements can be feasibly made.

8.6 Directions for future research

Future research could build on this thesis in three ways. Firstly, studies could be done for alternative fruits in South Africa. For example, the study could be replicated for other deciduous fruits. This would be valuable in providing more insights into how the broad deciduous fruit industry performs in terms of aligning to novel business environment demands. In addition, decisions on peach and nectarines are often made in conjunction with other stone or deciduous fruits in general. Hence, the provision of other comparable results could provide more insights. Secondly, the gravity model could be modelled from region to region as the results have shown that product value propositions exhibited different demand trends in the geographical markets. Lastly, the grow-share analysis could be done at country level given the accessibility of data that is broken down to that level.

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APPENDICES

Appendix A: SPSS Output for Manuscript 2

Reliability tests

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.464
Bartlett's Test of Sphericity	Approx. Chi-Square	56.795
	df	28
	Sig.	.001

Factor loading

Component Matrix[a]

	Component		
	1	2	3
skin colour	.691	.058	-.273
Growth habit	-.505	-.011	.323
Stone / firmness	.375	.720	.040
Flesh colour	.510	-.531	.239
Fruit size	.252	.294	-.082
fruit shape	.259	.202	.627
Harvest period ranked	-.114	.395	.542
Chilling req / Vigor	-.291	.433	-.461

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

PCA extraction and eigenvalues

Correlation Matrix[a]

		Harvest period ranked	Chilling req / Vigor	Growth habit	Fruit size	Flesh colour	Stone / firmness	fruit shape	skin colour
Correlation	Harvest period ranked	1.000	-.006	.062	.015	-.045	.102	.069	-.070
	Chilling req / Vigor	-.006	1.000	.050	-.118	-.183	.097	-.064	.032
	Growth habit	.062	.050	1.000	-.011	-.048	-.092	.015	-.149
	Fruit size	.015	-.118	-.011	1.000	-.072	.131	-.058	.081
	Flesh colour	-.045	-.183	-.048	-.072	1.000	-.072	.062	.189
	Stone / firmness	.102	.097	-.092	.131	-.072	1.000	.145	.137
	fruit shape	.069	-.064	.015	-.058	.062	.145	1.000	.028
	skin colour	-.070	.032	-.149	.081	.189	.137	.028	1.000

a. Determinant = ,772

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.361	17.017	17.017	1.361	17.017	17.017	1.319	16.486	16.486
2	1.275	15.932	32.949	1.275	15.932	32.949	1.270	15.869	32.355
3	1.143	14.286	47.235	1.143	14.286	47.235	1.190	14.879	47.235
4	1.092	13.655	60.890						
5	.912	11.405	72.295						
6	.890	11.130	83.425						
7	.693	8.662	92.087						
8	.633	7.913	100.000						

Extraction Method: Principal Component Analysis.

Appendix B: STATA Output for Manuscript 3

Pooled Ordinary Least Squares regression

```
. reg lnSA_IMPORTS Sus_Cons_Index Number_of_tarifflines Qlty_Index NTBs lnIMPvar lnTotalPOP Colonial_ties lnSA_GDP lnGDP Supp_Inde lnDist_AG d_imp
> _SHem
```

Source	SS	df	MS	Number of obs	=	329
				F(12, 316)	=	40.48
Model	732.084091	12	61.0070076	Prob > F	=	0.0000
Residual	476.263306	316	1.50716236	R-squared	=	0.6059
				Adj R-squared	=	0.5909
Total	1208.3474	328	3.68398597	Root MSE	=	1.2277

lnSA_IMPORTS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sus_Cons_Index	-.0147555	.0065345	-2.26	0.025	-.0276121	-.001899
Number_of_tarifflines	-.7591394	.0977488	-7.77	0.000	-.9514602	-.5668187
Qlty_Index	.0053709	.0120227	0.45	0.655	-.0182837	.0290255
NTBs	-.0345264	.0088195	-3.91	0.000	-.0518788	-.017174
lnIMPvar	.5020446	.4122969	1.22	0.224	-.3091494	1.313239
lnTotalPOP	.4616224	.0657145	7.02	0.000	.3323291	.5909156
Colonial_ties	2.162424	.2745936	7.87	0.000	1.622161	2.702687
lnSA_GDP	2.249248	3.079655	0.73	0.466	-3.809973	8.308468
lnGDP	1.316281	.0941382	13.98	0.000	1.131064	1.501498
Supp_Index	.0041165	.0115574	0.36	0.722	-.0186226	.0268556
lnDist_AG	-.7593609	.1144431	-6.64	0.000	-.9845277	-.5341941
d_imp_SHem	.0000127	.0000112	1.13	0.258	-9.37e-06	.0000348
_cons	-27.58447	27.63839	-1.00	0.319	-81.96298	26.79404

Random Effect Model results

```
. reg lnSA_IMPORTS Sus_Cons_Index Number_of_tarifflines Qlty_Index NTBs lnIMPvar lnTotalPOP Colonial_ties lnSA_GDP lnGDP Supp_Inde
> _SHem
```

Source	SS	df	MS	Number of obs	=	329
				F(12, 316)	=	40.48
Model	732.084091	12	61.0070076	Prob > F	=	0.0000
Residual	476.263306	316	1.50716236	R-squared	=	0.6059
				Adj R-squared	=	0.5909
Total	1208.3474	328	3.68398597	Root MSE	=	1.2277

lnSA_IMPORTS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sus_Cons_Index	-.0147555	.0065345	-2.26	0.025	-.0276121	-.001899
Number_of_tarifflines	-.7591394	.0977488	-7.77	0.000	-.9514602	-.5668187
Qlty_Index	.0053709	.0120227	0.45	0.655	-.0182837	.0290255
NTBs	-.0345264	.0088195	-3.91	0.000	-.0518788	-.017174
lnIMPvar	.5020446	.4122969	1.22	0.224	-.3091494	1.313239
lnTotalPOP	.4616224	.0657145	7.02	0.000	.3323291	.5909156
Colonial_ties	2.162424	.2745936	7.87	0.000	1.622161	2.702687
lnSA_GDP	2.249248	3.079655	0.73	0.466	-3.809973	8.308468
lnGDP	1.316281	.0941382	13.98	0.000	1.131064	1.501498
Supp_Index	.0041165	.0115574	0.36	0.722	-.0186226	.0268556
lnDist_AG	-.7593609	.1144431	-6.64	0.000	-.9845277	-.5341941
d_imp_SHem	.0000127	.0000112	1.13	0.258	-9.37e-06	.0000348
_cons	-27.58447	27.63839	-1.00	0.319	-81.96298	26.79404

Fixed Effects Model results

```
                                        F(9,298)          =     21.92
corr(u_i, Xb)  = -0.4526                Prob > F          =    0.0000
```

lnSA_IMPORTS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sus_Cons_Index	-.0204987	.0040696	-5.04	0.000	-.0285074	-.01249
Number_of_tarifflines	0	(omitted)				
Qlty_Index	.0054581	.007625	0.72	0.475	-.0095476	.0204637
NTBs	-.0648979	.0128659	-5.04	0.000	-.0902173	-.0395784
lnIMPvar	.7979272	.2478576	3.22	0.001	.3101541	1.2857
lnTotalPOP	.2794115	.169781	1.65	0.101	-.0547102	.6135331
Colonial_ties	0	(omitted)				
lnSA_GDP	3.968629	1.891095	2.10	0.037	.247037	7.690221
lnGDP	1.285974	.4169715	3.08	0.002	.4653921	2.106556
Supp_Index	-.0004219	.0070576	-0.06	0.952	-.0143109	.0134671
lnDist_AG	0	(omitted)				
d_imp_SHem	.0000119	6.80e-06	1.75	0.080	-1.45e-06	.0000253
_cons	-47.15186	17.32233	-2.72	0.007	-81.24145	-13.06227
sigma_u	1.7321438					
sigma_e	.73169735					
rho	.84857864	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(21, 298) = 56.46                     Prob > F = 0.0000

.
```

Hausman test results

```
Note: the rank of the differenced variance matrix (8) does not equal the number of coefficients being tested (9); be sure this is what you expect,
      or there may be problems computing the test.  Examine the output of your estimators for anything unexpected and possibly consider scaling
      your variables so that the coefficients are on a similar scale.
```

	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Sus_Cons_I~x	-.0204987	-.019564	-.0009347	.0004932
Qlty_Index	.0054581	.0038181	.0016399	.000951
NTBs	-.0648979	-.0557022	-.0091957	.005912
lnIMPvar	.7979272	.783725	.0142022	.
lnTotalPOP	.2794115	.3886826	-.1092711	.1109483
lnSA_GDP	3.968629	3.860904	.1077247	.
lnGDP	1.285974	1.375454	-.0894797	.3573919
Supp_Index	-.0004219	-.0009157	.0004937	.
d_imp_SHem	.0000119	.0000117	2.65e-07	3.69e-07

```
                    b = consistent under Ho and Ha; obtained from xtreg
     B = inconsistent under Ha, efficient under Ho; obtained from xtreg

  Test:  Ho:  difference in coefficients not systematic

                chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                        =        2.44
              Prob>chi2 =      0.9643
              (V_b-V_B is not positive definite)
```

Breusch-Pagan test results

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        lnSA_IMPORTS[countrynum,t] = Xb + u[countrynum] + e[countrynum,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                lnSA_IM~S |   3.683986       1.919371
                       e |    .535381       .7316974
                       u |   .8725445       .9341009

        Test:   Var(u) = 0
                                chibar2(01) =   913.78
                            Prob > chibar2 =   0.0000
```

Appendix C: SPSS Output for Manuscript 4

Number of Cases in each Cluster

Cluster	1	93.000
	2	123.000
Valid		216.000
Missing		.000

Cluster Membership

Case Number	Cluster	Distance
1	1	2.424
2	2	2.137
3	2	1.472
4	2	2.687
5	2	1.472
6	1	1.658
7	1	.918
8	2	2.788
9	1	2.269
10	1	1.884
11	1	2.035
12	1	2.343
13	1	1.114
14	1	1.162
15	1	1.261
16	2	2.370
17	1	1.685
18	1	1.374
19	1	2.558
20	1	1.578
21	1	2.204
22	1	1.279
23	1	2.218
24	1	1.374
25	2	1.905
26	2	1.533
27	1	1.184
28	2	.887

29	1	1.336
30	2	1.771
31	2	2.682
32	1	1.308
33	1	1.929
34	1	1.906
35	2	2.251
36	2	2.129
37	2	2.075
38	1	1.582
39	2	2.191
40	2	2.584
41	2	1.261
42	2	1.920
43	2	1.286
44	2	2.092
45	2	1.199
46	1	1.822
47	2	2.681
48	1	2.678
49	1	1.083
50	2	1.276
51	2	1.577
52	2	1.462
53	2	2.773
54	2	1.276
55	1	1.321
56	1	.898
57	2	2.560
58	1	2.309
59	2	1.261
60	1	.898
61	1	.895
62	2	1.552
63	1	.833
64	1	2.263
65	2	1.628
66	1	1.666
67	2	1.865
68	1	1.816

69	1	2.941
70	1	1.543
71	2	1.287
72	2	1.422
73	2	2.825
74	2	2.075
75	2	2.825
76	1	1.215
77	1	2.845
78	1	1.342
79	2	2.180
80	2	2.825
81	2	1.276
82	1	2.085
83	2	1.291
84	2	1.495
85	2	1.495
86	2	1.291
87	2	1.291
88	2	1.693
89	2	1.900
90	1	1.564
91	1	1.453
92	1	1.374
93	2	1.199
94	2	1.139
95	1	1.528
96	2	1.617
97	1	1.131
98	2	1.291
99	1	2.823
100	2	.662
101	2	2.402
102	2	1.960
103	2	.662
104	1	2.016
105	1	1.374
106	1	1.043
107	1	.837
108	2	1.520

109	2	1.495
110	2	1.291
111	2	1.721
112	1	2.090
113	2	2.533
114	1	1.131
115	2	1.291
116	2	1.261
117	2	1.614
118	1	2.012
119	2	2.342
120	2	1.473
121	2	1.118
122	1	1.083
123	2	3.029
124	2	2.416
125	2	1.111
126	2	1.473
127	2	1.371
128	2	.885
129	1	1.345
130	2	1.418
131	2	1.428
132	1	1.559
133	1	1.527
134	2	1.615
135	2	1.617
136	1	1.186
137	2	1.905
138	2	2.435
139	1	2.127
140	1	2.118
141	2	2.560
142	1	2.762
143	2	1.118
144	1	.972
145	1	2.528
146	1	2.964
147	1	2.508
148	1	1.674

149	1	2.738
150	1	2.120
151	1	.837
152	1	1.162
153	2	2.323
154	1	1.353
155	1	2.722
156	2	1.015
157	1	2.193
158	2	1.495
159	2	1.276
160	1	.373
161	1	1.991
162	2	.437
163	2	1.535
164	1	1.804
165	2	1.669
166	2	1.950
167	2	2.388
168	2	1.985
169	2	1.287
170	2	1.816
171	2	1.284
172	2	2.129
173	2	3.163
174	1	.992
175	2	1.925
176	1	2.206
177	1	2.055
178	2	1.737
179	2	1.628
180	2	1.367
181	2	.820
182	2	1.368
183	1	2.161
184	2	1.272
185	2	1.495
186	2	1.122
187	2	2.069
188	2	2.318

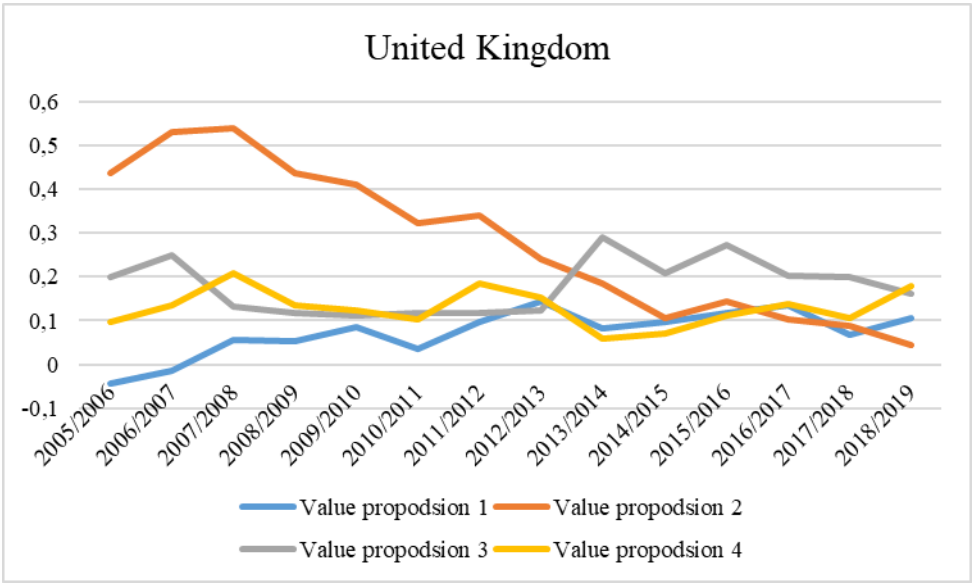
189	2	1.495
190	2	.527
191	1	1.804
192	2	1.693
193	2	1.594
194	2	1.929
195	1	1.257
196	2	1.706
197	2	1.225
198	2	1.920
199	2	2.820
200	2	1.737
201	2	1.718
202	2	1.481
203	1	2.428
204	2	.946
205	1	3.229
206	1	2.289
207	1	2.289
208	1	.996
209	1	2.030
210	1	.752
211	2	1.323
212	2	1.175
213	1	2.466
214	1	2.215
215	2	1.291
216	2	.929

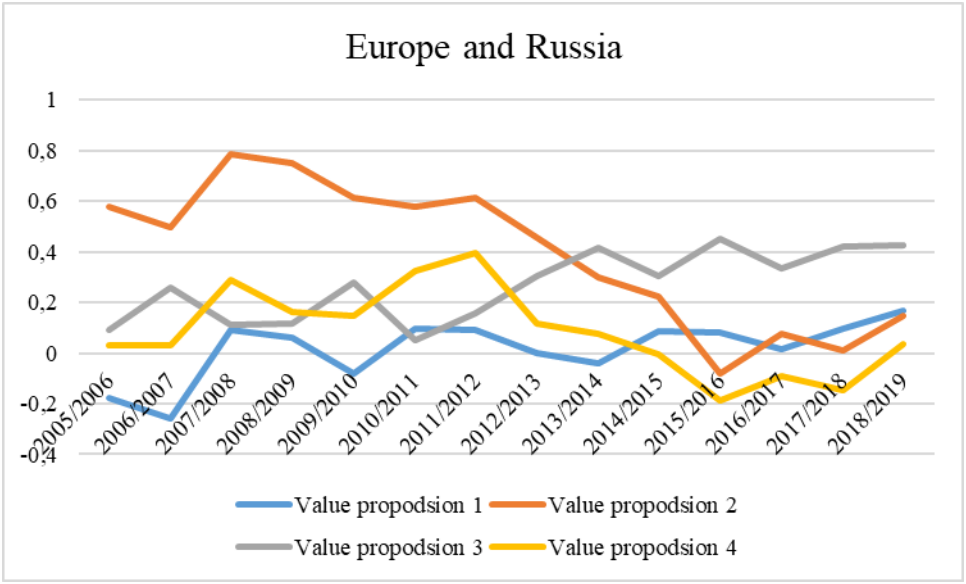
ANOVA

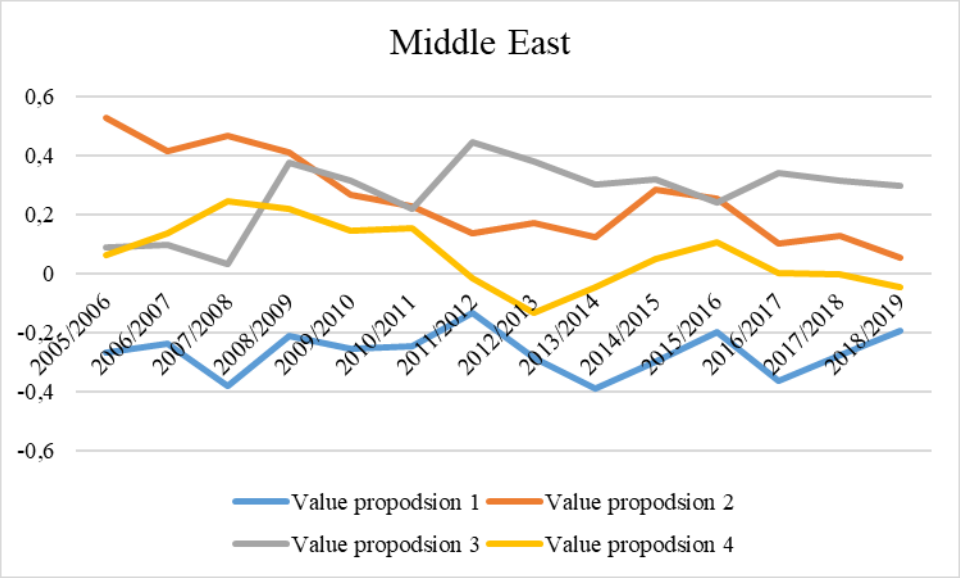
	Cluster		Error			
	Mean Square	df	Mean Square	df	F	Sig.
REGR factor score 1 for analysis 1	122.021	1	.434	214	280.842	.000
REGR factor score 2 for analysis 1	18.507	1	.918	214	20.156	.000
REGR factor score 3 for analysis 1	2.707	1	.992	214	2.729	.100
REGR factor score 4 for analysis 1	3.068	1	.990	214	3.098	.080

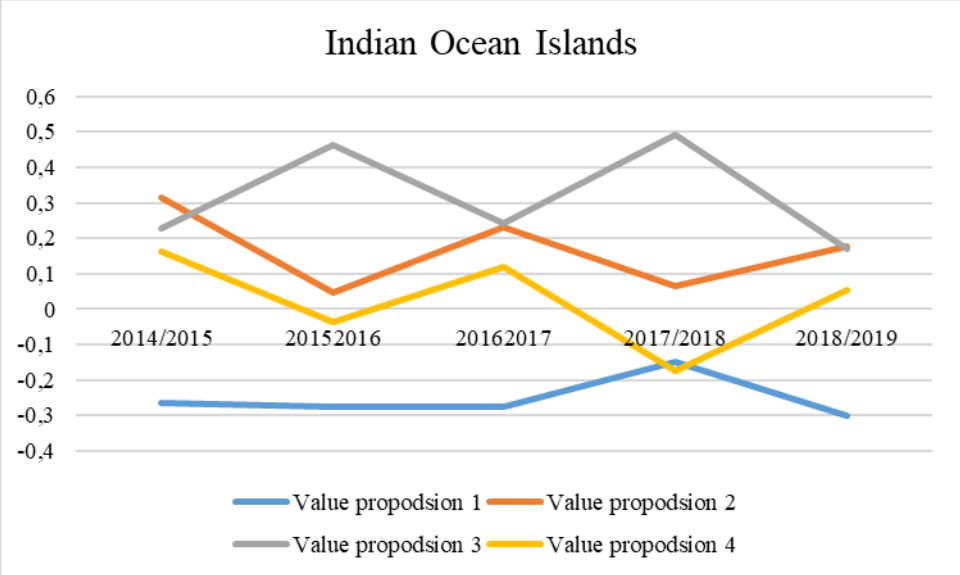
The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

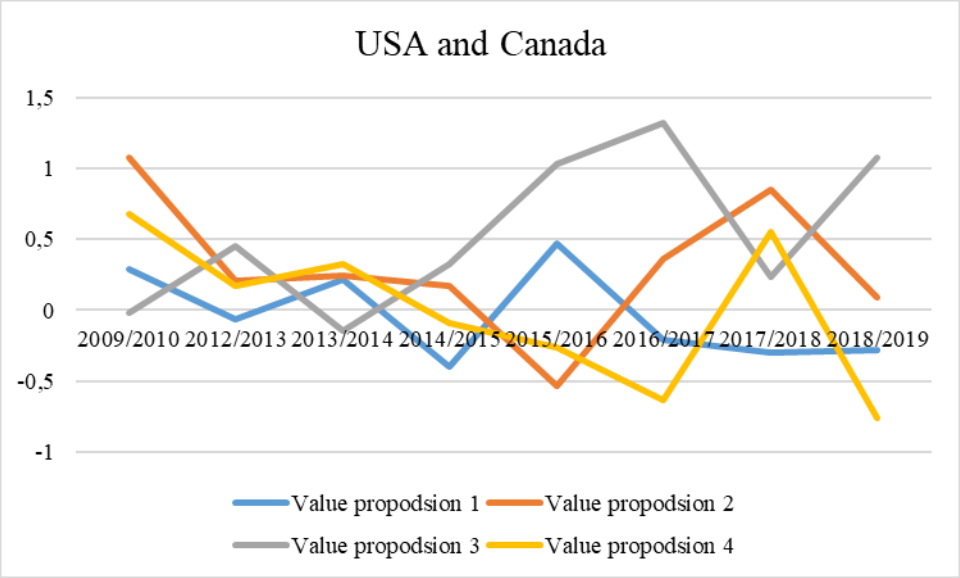
Appendix D: Microsoft Excel Output for Manuscript 5

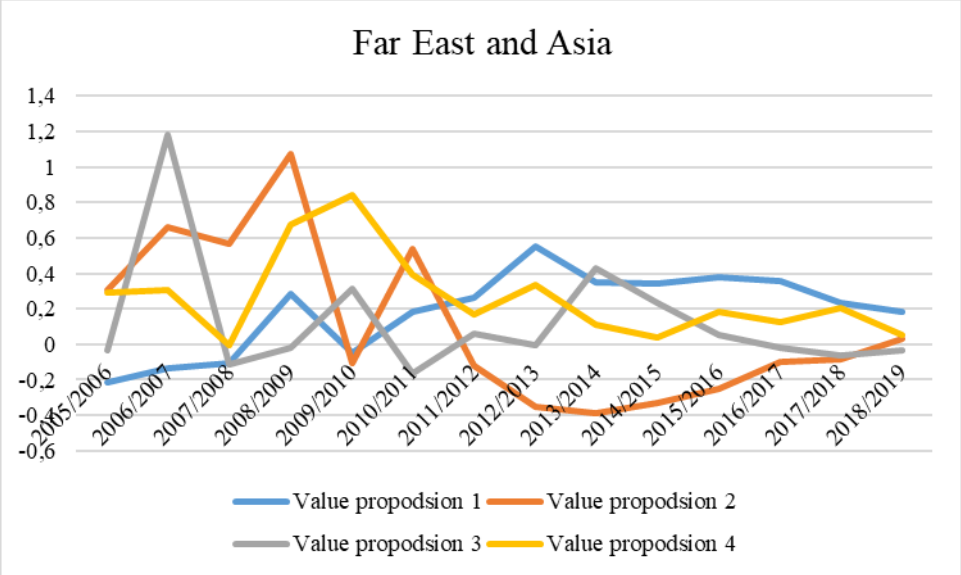


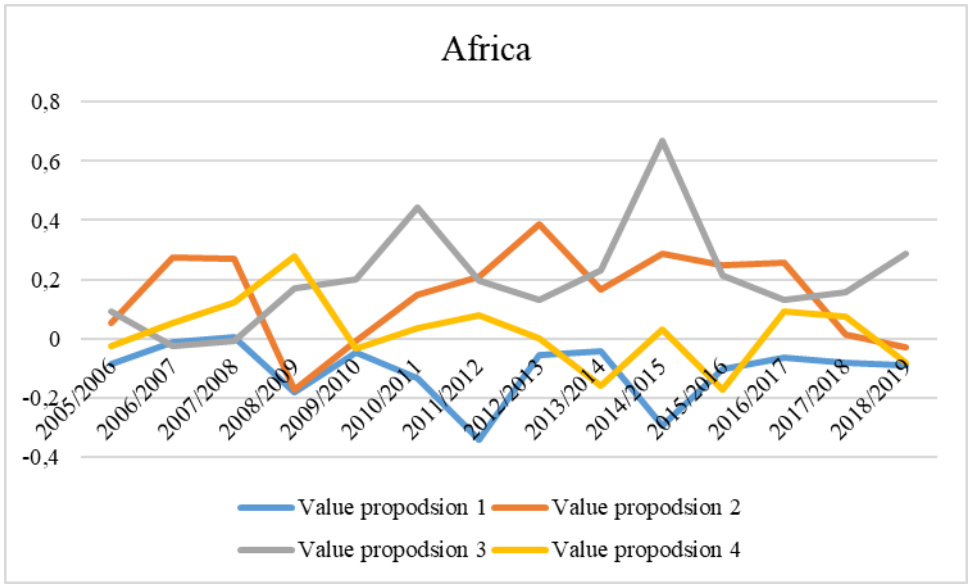



Middle East
0,6
0,4
0,2
0
-0,2
-0,4
-0,6
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
Value propodsion 1
Value propodsion 2
Value propodsion 3
Value propodsion 4


Indian Ocean Islands
0,6
0,5
0,4
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
-0,4
2014/2015
20152016
20162017
2017/2018
2018/2019
Value propodsion 1
Value propodsion 2
Value propodsion 3
Value propodsion 4

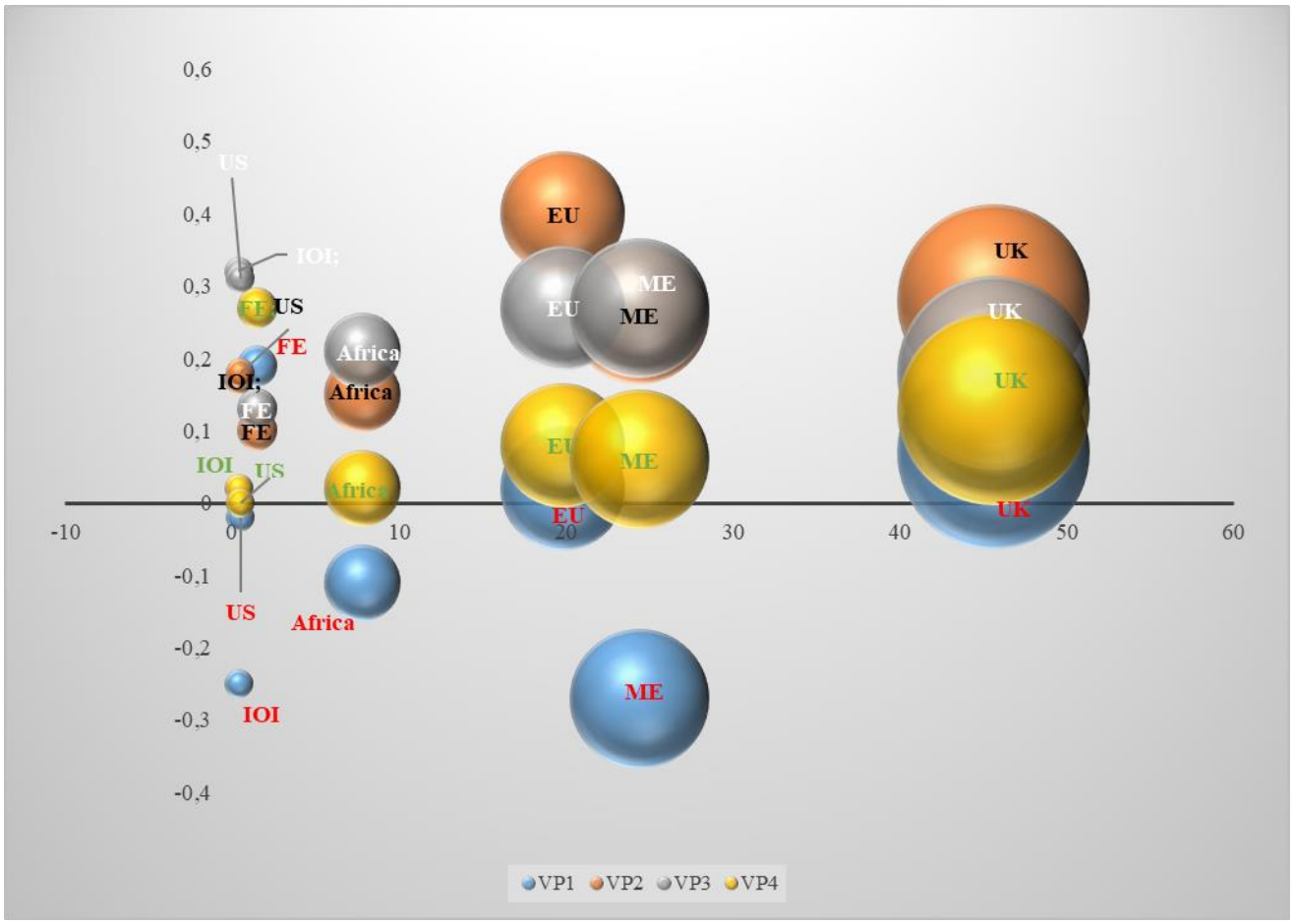

USA and Canada
1,5
1
0,5
0
-0,5
-1
2009/2010 2012/2013 2013/2014 2014/2015 2015/2016 2016/2017 2017/2018 2018/2019
Value propodsion 1
Value propodsion 2
Value propodsion 3
Value propodsion 4


Far East and Asia
1,4
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
-0,4
-0,6
2005/2006
2006/2007
2007/2008
2008/2009
2009/2010
2010/2011
2011/2012
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
Value propodsion 1
Value propodsion 2
Value propodsion 3
Value propodsion 4



	Mkt Share	VP1	Bubble size
UK	45,6	0,07	4,6
EU	19,8	0,02	1,9
ME	24,4	-0,27	2,4
IOI	0,4	-0,25	0,1
FE	1,5	0,19	0,2
US	0,5	-0,02	0,1
Africa	7,8	-0,11	0,7

	Mkt Share	VP2	Bubble size
UK	45,6	0,28	4,6
EU	19,8	0,4	1,9
ME	24,4	0,26	2,4
IOI	0,4	0,17	0,1
FE	1,5	0,1	0,2
US	0,5	0,18	0,1
Africa	7,8	0,15	0,7

	Mkt Share	VP3	Bubble size
UK	45,6	0,18	4,6
EU	19,8	0,27	1,9
ME	24,4	0,27	2,4
IOI	0,4	0,32	0,1
FE	1,5	0,13	0,2
US	0,5	0,31	0,1
Africa	7,8	0,21	0,7

	Mkt Share	VP4	Bubble size
UK	45,6	0,13	4,6
EU	19,8	0,08	1,9
ME	24,4	0,06	2,4
IOI	0,4	0,02	0,1
FE	1,5	0,27	0,2
US	0,5	0	0,1
Africa	7,8	0,02	0,7