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International food safety standards and South Africa's orange exports to key Asian markets: An analysis based on the gravity model using three-dimensional data

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Abstract

This paper aims to analyze the impact of food safety regulations imposed by strategic Asian countries on South Africa's orange exports to these markets. The analysis employed a gravity model with three-dimensional data from 2003 to 2022. The model indicates that the influence of descriptive variables is significant with an f-statistic significant at the 1% level and an adjusted R-squared of 0.580 suggesting that variables account for a considerable share of variation in orange exports. It was revealed that an increase in the importer's GDP of 1% decreases South Africa's export performance while a rise in South Africa's GDP enhances it. Population growth positively influences export volumes. Furthermore, the exchange rate volatility at the 5% level supports rather than hinders export growth suggesting resilience within the industry. Notably, TBT measures positively and significantly influence orange exports contrary to fears that food safety issues might impede exports. In contrast, the insignificant and negative coefficient for SPS measures suggests a counterproductive effect on South African orange exports about food safety standards. Findings highlight crucial factors that affect and enhance South Africa's orange export growth providing important insights for policymakers and stakeholders in the agricultural export sector to navigate food safety regulations and optimize export strategies.

Keywords: Asian strategic markets, Competitiveness, Food safety standards, Gravity model, Hausman test, Orange exporters, Phytosanitary barrier, Technical barrier.

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1. Introduction

In an increasingly globalized world, the significance of international food safety standards have become paramount for countries engaged in agricultural exports. The ability to ensure food safety and quality emerges as a critical determinant for success in competitive international markets as trade barriers continue to dissolve and markets expand beyond borders. Food safety standards play a pivotal role not only in safeguarding public health but also in enhancing consumer preference, facilitating trade relations and ensuring compliance with the stringent regulatory requirements imposed by importing countries. According to Salajegheh et al. [1] food safety concerns have become widespread due to issues such as domestic food shortages, market fluctuations, and emergency trade bans affecting the import and export of various commodities. In some countries, unethical practices among traders have exploited consumers through unfair trade leading to the consumption of contaminated foods and resulting in numerous foodborne illnesses [2].

Countries are prioritizing the safety and quality of food products before they enter into international trade and all imported foods must meet the standards set by the importing nation. However, food safety regulations can occasionally serve as obstacles to international trade. Furthermore, the proliferation of these regulations have added complexity to trade policy negotiations and efforts to enhance agricultural trade [3]. It has been observed that the costs associated with complying with new food safety standards have raised concerns about potential losses in competitiveness for countries. Furthermore, the increasing prevalence of diverse food standards and their implementation poses challenges to the international food market. Effective food safety standards play a crucial role in enhancing competitive performance in global markets. According to Dipali et al. [4] the impact of food safety standards on driving competitiveness is more pronounced than those of other factors while there is a relationship between these two aspects.

The competitiveness of the South African orange industry depends on various domestic and international factors. According to Ndou and Obi [5] to succeed in local markets, adherence to both global and South African Good Agricultural Practices (GAP) is essential. A considerable gap exists in understanding the specific food safety requirements of Asian markets and how South African exporters navigate these regulations although there is significant potential for growth in orange exports. Previous studies have focused on food safety standards in isolation and domestic compliance leaving an important void regarding the intersection of food safety regulations and international trade dynamics. Mphaga et al. [6] investigated South Africa's food control and safety landscape revealing that financial misrepresentation of food products occurs due to lack of inspectors and laboratories. This study aims to address this gap by examining how South African orange exports align with the food safety standards required by key Asian markets and the implications for South African exporters.

Literature indicates that establishing a Food Safety Systems (FSS) management framework within the trade context is crucial for recognizing the importance of industry stakeholders in ensuring food safety.Santacoloma and Casey [7] highlighted that this recognition is vital for enhancing competitiveness in strategic markets and presents an opportunity to increase export market share. This paper explores the complex relationship between international food safety standards and South African orange exports focusing on key Asian markets. We aim to underscore the significance of robust food safety systems as a foundation for successful international trade and provide practical recommendations for enhancing food safety protocols by assessing the impact of food safety regulations on South African orange exports. The central question addressed is as follows: How do Asian food safety standards affect South African orange exports? The structure of this paper includes the following sections: introduction, trade theory, literature review, methodology, results and discussions, conclusion and recommendations.

1.1. The Study Aim, Objectives, and Hypotheses

The research seeks to assess how food safety standards impact the export of oranges from South Africa to specific strategic markets.

1.2. The Objectives of the Study

Assessing the impact of food safety regulations on the export success of South African oranges to major Asian markets.

1.3. Study Question

Do food safety standards have a significant impact on South Africa's orange exports to crucial Asian markets?

2. Literature Review

The World Health Organization (WHO) is currently observing significant changes in the consumption, production, processing, and distribution of food products marking an unprecedented shift in global food systems [8]. This evolving landscape is shaped by lifestyle choices, economic shifts, technological advancements, and climate change have the potential to either enhance or threaten food safety. Multiple food hazards can arise at any stage of the food supply chain, leading to various health issues including illnesses and fatalities. As we approach 2050, projections indicate that two-thirds of the global population will reside in megacities with populations exceeding ten million. This underscores the urgent need for food systems to adapt. Urbanization presents critical challenges related to food supply, sanitation and hygiene, food waste management, and water scarcity necessitating robust investments and commitments to safeguard the health of rapidly growing urban populations [8].

Previous studies have extensively examined the implications of food safety standards on agricultural and food trade, yielding a spectrum of results (e.g., Chen et al. [9]; Fiankor et al. [10] and Mao et al. [11]). For instance, Chen et al. [12]

utilized a gravity model within a difference-in-differences framework to analyze the US market and found that Hazard Analysis Critical Control Points (HACCP) regulations did not significantly affect US seafood imports. In contrast, research by Jongwanich and Magtibay-Ramos [13] suggested that sanitary and phytosanitary (SPS) measures in the US could act as barriers to processed food imports from developing nations. However, their reliance on a three-year average data period may introduce potential bias into their findings. Utilizing import detention data as a proxy for SPS measures could overlook nuances as not all detained shipments equate to outright denials and compliance with food safety standards may still facilitate market access for exporters.

Further investigation into econometric models assessing the effects of domestic policies on bilateral trade flows particularly between South Africa and key Asian markets reveal a growing focus on gravity models. These models illustrate the varying impacts of SPS measures on food trade dependent on the economic development levels of importing countries. Recent findings by Santeramo and Lamonaca [14] highlight a positive relationship between SPS and technical barriers to trade (TBT) imposed by developing countries and their food import volumes suggesting that such measures may not always be restrictive. Their analysis indicates that a higher number of SPS measures does not inherently signal restrictive practices; instead, it reflects a commitment to maintaining food safety standards while encouraging trade.

Moreover, recent studies such as those by Kharel et al. [2] and Ulimwengu et al. [15] have further illuminated the complexities of trade and food safety. Kharel et al. [2] analyzed international regulatory frameworks and their impact on food safety compliance finding that stringent regulations in importing countries often lead to improved food safety outcomes in exporting countries. Similarly, Ulimwengu et al. [15] explored how digital technology enhances traceability within global food supply chains, potentially mitigating food safety risks and promoting consumer confidence.

In conclusion, as global food systems confront multifaceted challenges, the continuous assessment of food safety standards in relation to trade dynamics is crucial. Recent research highlights the ongoing evolution of frameworks that aim to balance safety with market accessibility, highlighting the vital role of both developed and developing nations in navigating these complexities. Addressing these issues are essential not only for ensuring food safety but also for fostering sustainable food trade practices in a rapidly urbanizing world.

3. Trade Theory

Since the groundbreaking research of Tinbergen [16] it has been recognized that the volume of bilateral trade between two countries can be explained by a principle known as "gravity" which parallels Newton's gravitational theory. This analogy implies that the trade volume is influenced by the economic sizes of the countries involved and their geographical proximity. Initially conceptualized by UNCTAD [17] the gravity equation highlighted a consistently observed relationship among economic size, geographical distance, and trade volume. During this time, the dominant models of international trade included the Ricardian model which explains trade patterns based on technological differences between nations, and the Heckscher-Ohlin (HO) model which focuses on differences in factor endowments [18]. At the time, it was argued that traditional Ricardian and HO models lacked the robustness necessary to provide a foundation for the gravity model particularly in the HO framework, a country's size was deemed to have little impact on trade flow structures [18].

The gravity equation's remarkable stability and effectiveness in illuminating bilateral trade patterns have spurred efforts to develop a theoretical foundation. Although empirical analysis initially led the way, gravity has now been recognized as a fundamental component in most trade models. A significant early attempt to create a theoretical basis for gravity models came from Anderson [19]. His framework posited that products are differentiated by their country of origin with consumers possessing preferences for a variety of these distinct products based on the Armington assumption. This model indicates that regardless of price, consumers in a country would purchase some quantity of every goods from each exporting nation. It assumes that all goods are tradable, every nation participates in international trade, and in equilibrium, national income results from domestic and international demand for the unique goods produced by each country. Consequently, larger countries tend to import and export more UNCTAD [17].

Waugh [20] further contributed to the theoretical understanding of trade by modeling trade costs as "iceberg" costs, where only a portion of the goods shipped reach their destination with the remainder "melting" away during transit. This perspective posits that if imports are evaluated at their costs inclusive of freight and insurance (CIF), transportation costs act as a significant barrier to trade flows.

4. Methodology

The current section effectively introduces the significance of trade conditions as recognized by various economists in the field. This encompasses the analysis of international trade and the evaluation of various factors' effects as outlined by Capoani [21]. Chaney [22] the pioneer of the gravity model sought to explain the magnitude of bilateral trade which can be determined using the Newtonian gravitational framework. This concept posits that the trade relationship between two countries is influenced by a force that is directly proportional to the product of their economic sizes and inversely proportional to the square of the distance separating them. Beghin and Bureau [23] succinctly express this theory with Equation 1.

$$T_{ij} = a_0 \frac{X_i^{a1} X_j^{a2}}{D_{ij}^{a3}} \qquad (1)$$

Where T_{ij} = Exports of country *i* to country *j*.

X_i^{a1} = Gross Domestic Product (GDP) of country *i*.

X_j^{a2} = Gross Domestic Product (GDP) of country *j*.

D_{ij}^{a3} = Distance between country i and country *j*.

a_0 = Is the general constant.

Tinbergen [16] noted that the key factors affecting the trade volume between two countries include the economic size of the exporting nation (measured by GDP), the economic size of the importing nation, and the distance separating them. Typically, a gravity model is represented through a logarithmic-linear relationship where the trade flow between the two nations can be expressed as a function of

- Two countries' income dimensions of economic size regarding their gross domestic products.
- Two countries' population estimates.
- The distance between the two countries.
- Factors of trade bending.

4.1. Analytical Methods

The research employs the gravity model as represented by Equation 1 to examine the influence of food safety standards on the export of South African oranges to significant Asian markets. The model has incorporated advanced econometric techniques of the gravity model such as including three dimensional-data while previous studies have relied on simpler gravity model, and two-dimensional approach leading to less comprehensive findings. Metri et al. [24] utilized a basic model to measure determinants of export in a small open economy and identified a need to explore more dimensional data to get relevant sights. The gravity model is a well-acknowledged approach to studying international trade dynamics between nations [25]. In this empirical investigation, varying food safety standards are incorporated with the expectation that these standards will reduce the competitiveness of South Africa's orange exports. Consequently, the gravity model utilized in this study will adopt the following functional form:

$$logXijt = \beta 0 + \beta 1(logGDPit) + \beta 2(logGDPjt) + \beta 3(logDISij) + \beta 4(logEPIit) + \beta 5(logIPIjt) + \beta 6(logSPSi) + \beta 7(logTBTi) + \beta 8(logPRODi) + \beta 9(logPOPi) + \beta 10(logINFi) + \beta 11(logREXRi) + \beta 12(logREXRsat) + \varepsilon i + \eta t$$

Table 1.
Variables description and expected influence.

Variable name	Description	Sign.
Exports	The quantity of fruits exported in tons.	**(+)**
SA GDP	Value of GDP of country i at time t.	(+)
Importers GDP	Value of GDP of country j at time t.	(+) or (-)
Export price index	Export price index of country i at time t.	(+) or (-)
Import price index	Import price index of country j at time t.	(+)
Distance	Distance between country i and j.	(-)
Sanitary and phytosanitary	Level of SPS imposed by importers at time t.	(-)
Technical barriers to trade	Level of TBT imposed by importers at time t.	(-)
Production capacity	Production capacity of South Africa at the time.	(+)
Importers population	Population-level of country j at time t.	(+)
Inflation rate	The inflation rate of country j at time t.	(+)
Exchange rate	South Africa's exchange rate against its trading partners at the time t.	(+)
Importers exchange rate	The importer's exchange rate against the US dollar at time t.	(-)
ε_{ijt}	An error term assumed to be normally distributed.	(+) or (-)

Source: Own construction supported by literature.

4.2. Data

The research utilized secondary panel data, obtaining export information from the International Trade Commission (ITC) and sourcing GDP, population, and exchange rate data from the World Bank. Distance data between the involved countries was sourced from Center for Prospective Studies and International Information (CEPII). This paper utilizes the secondary panel data spanning from 2003 to 2022 which provides a comprehensive view of trends and changes over a significant period. Many studies have used shorter time frames or more limited data sets potentially missing long-term trends or shifts in patterns. Additionally, the paper includes new emerging markets in Asia have not been covered extensively in impact research. Previous studies have focused on European markets as traditional markets and omitted potential trade with Asian markets and also focused on bilateral trade.

5. Results and Discussion

The preparation of panel variables is strongly balanced during the period under review at a delta unit 1.

xtset country1 Year
Panel variable: Country1 (Strongly balanced).
Time variable: Year, 2003 to 2022.

Delta: 1 unit.

The research focused on a study area encompassing ten significant Asian markets from 2003 to 2022. The Hausman test was employed to identify the model that yielded the most precise results, with the fixed model demonstrating superior proficiency. An analysis of the data presented in Table 2 included a descriptive examination. Generally, factors regularly disseminated outperformed those that were less commonly diffused. The table displays the results of the normality test conducted on the variables.

Table 2.
Descriptive statistics of variables influencing SA orange exports.

Variables	Obs.	Mean	Std. dev	Min.	Max.
logXjt	200	7.155	3.426	0	11.921
logPOPjt	200	18.547	1.525	15.722	21.072
logEPIit	200	4.568	0.298	3.808	5.028
logGDPjt	200	27.320	1.364	24.401	30.519
logGDPsat	200	26.581	0.198	26.007	26.851
logIPIjt	200	4.461	0.444	2.725	5.299
logPRODsat	200	14.209	0.133	13.934	14.408
logSPSsaj	200	1.564	1.304	-0.970	3.340
logTBTsaj	200	6.355	0.770	4.175	8.208
logREXRjt	200	4.761	2.877	1.118	10.055
logINFsat	200	0.935	0.945	-3.38	3.141

Source: Own construction supported by literature.

A correlation matrix serves as a statistical instrument employed to evaluate the connection between two variables within a dataset. This matrix is essentially a table wherein each cell contains a correlation coefficient. A correlation coefficient of 1 signifies a robust association between variables, 0 indicates a neutral relationship and -1 indicates a weak relationship. By scrutinizing a basic correlation matrix of explanatory variables prior to parameter estimation, one can frequently anticipate the occurrence of multicollinearity, a statistical issue that complicates the identification of independent effects of different explanatory variables.

Table 3 displays the correlation matrix for the explanatory variables employed in the analysis. The objective is to illustrate the relationships among these factors. In the provided table, there is a neutral correlation between importers' exchange rate and South African GDP. With few exceptions, the majority of these variables exhibit strong connections. For instance, there are significant associations between SA exports and importers' exchange rate (as well as SA inflation), export price index and SPS, importers' GDP and SA inflation (along with Importers exchange rate), and so forth. Consequently, the coefficients presented in the table below suggest that concerns regarding multicollinearity do not pose a hindrance to model determination.

Table 3.
Correlation matrix of explanatory variables.

Variables	$logX_{jt}$	$logPOP_{jt}$	$logEPI_{it}$	$logGDP_{jt}$	$logGDP_{sat}$	$logIPIjt$	$logPROD_{sat}$	$logSPSsaj$	$logTBT_{saj}$	$logREXR_{jt}$	$logINF_{sat}$
$logX_{jt}$	1										
$logPOP_{jt}$	0.0603	1									
$logEPI_{it}$	0.0625	0.0265	1								
$logGDP_{jt}$	0.1116	0.6172	0.2763	1							
$logGDP_{sat}$	0.0736	0.0231	0.9455	0.25	1						
$logIPI_{jt}$	0.0399	-0.022	0.8331	0.3759	0.7655	1					
$logPROD_{sat}$	0.0327	0.0247	0.5587	0.2326	0.4494	0.5966	1				
$logSPS_{saj}$	0.1147	0.0999	-0.0338	0.1639	-0.0389	-0.0753	-0.0286	1			
$logTBT_{saj}$	0.2463	0.0739	0.0158	0.2842	0.0095	0.1749	0.0182	-0.1229	1		
logREXRjt	-0.378	0.1067	0.0023	-0.1402	0	-0.0794	0.0099	-0.2768	-0.076	1	
$logINF_{sat}$	-0.0373	0.2418	0.0067	-0.2731	0.0456	-0.2098	-0.1739	0.1094	-0.2237	0.2686	1

Source: Own construction supported by literature.

Table 4 shows the impact of gravity conditions. This table depicts the consequences of pooling, fixed, and random effects as identified through the STATA software. The remarkable outcomes of these three impacts are highlighted, particularly with the fixed effects model revealing heterogeneity through an examination of national impacts. To assess the validity of the introduced models and their results, the Hausman test was employed. Eita [26] asserts that the Hausman test helps identify any lack of connection between components in the model indicating potential errors in the theory.

The outcomes from the fixed effects model outlined in Table 4 indicates that a 1% growth in the GDP of both South Africa and importing countries correlate with a boost in South Africa's orange export performance. In simpler terms, when the GDP of South Africa and its trading partners increases, the export of oranges from South Africa also increases. The influential factors demonstrate a consistently positive relationship aligning well with economic principles. Sumiyati [27] finds that the GDP on lag 1 has a positive impact on the manufacturing export in line with the theoretical expectations. Consequently, a rise in GDP for key Asian nations contributes to a higher production volume leading to an increased demand for imported fruits specifically intended for further processing. The outcomes concluded that a rise in GDP influences Pakistan's currency to appreciate and enhance Pakistan's exports [28].

The populations of strategic markets in Asia demonstrate a statistically significant and positive trend. In theory, a positive correlation is expected between the population of importing countries and South Africa's orange export performance. This suggests that the growth in population within critical Asian markets positively influences South African exports aligning with theoretical predictions. This is aligned with Bulut and Yaşar [29]. The results indicate that the exchange rate significantly influences exports at different levels. Furthermore, the study found a 5% negative effect on the South African exchange rate. The detrimental impact of real exchange rate fluctuations on South African orange exports suggests a potential risk-averse tendency within the country's orange sector. Jyoti [30] also concluded that the long-term increases in the exchange rate have a positive impact on Indian exports. This aligns with Zhu et al.'s [31] suggestions made by those who determined that the exchange rate policies adopted by Asian countries had a favourable impact on economic growth via exports.

Table 4.
Estimated results of South Africa's orange exports.

Variables	Pooled model	Fixed effects	Random effects model
logGDPjt	-1.48 (0.140) *	2.60 (0.010) ***	1.31 (0.190)
logGDPsat	1.85 (0.066) *	1.43 (0.153) *	0.42 (0.677)
logIPIjt	-1.19 (0.234)	-1.11 (0.268)	-0.03 (0.976)
logPRODsat	0.21 (0.834)	0.08 (0.932)	-0.12 (0.907)
logSPSsaj	-0.20 (0.838)	-0.64 (0.522)	-0.48 (0.628)
logTBTsaj	5.87 (0.000) ***	2.75 (0.007) ***	2.37 (0.018) **
logREXRjt	-2.46 (0.015) **	-0.35 (0.726)	0.18 (0.859)
logREXRsat	0.91 (0.367)	2.07 (0.040) **	-0.85 (0.394)
logDISTsaj	-4.75 (0.000) ***	-	-1.35 (0.178) *
logINFsat	0.49 (0.626)	0.13 0.900	0.09 (0.928)
logPOPjt	-1.73 (0.086) *	3.06 (0.003) ***	-1.42 (0.154)
_cons	-0.77 (0.442)	1.96 (0.052)	0.80 (0.425)
Prob>F	0.0000	0.0015	0.0319
No. of observations	200	200	200
Adjusted R squared	0.6048	0.5796	0.4752
F-test	-	63.93***	-
LM test	-	-	-
Hausman test	-	0.0038***	-

Note: ***/**/* Significant at 1%/5%/10% level.

TBTs may lead to the departure of exporters as they increase the complexity and cost of export procedures [32, 33]. Typically, exporters with lower performance or productivity are more likely to exit markets imposing TBTs because they cannot afford the additional expenses required to adapt their products to stricter standards in TBT imposing countries. The primary concern factors affecting South African orange exports to key Asian nations are TBT and SPS measures. Initially, TBT measures for orange exports were found to be positive and statistically significant associated in pooled, fixed, and random effects analyses. It aligns with Bossoma [34]. The research indicates that technical barriers to trade (TBT) regulations enhance trade volumes with the effects varying based on the developmental status of the countries implementing these regulations. This suggests that TBT measures contribute to the promotion of South African orange exports contrary to concerns that food safety regulations might impede such exports. Conversely, the SPS coefficient is negative and not statistically significant indicating that these measures impede South African orange exports [35]. This aligns with Bossoma [34]. The SPS technical regulations often impose limitations that hinder trade for exporters from developing countries. Wang and Zhao [36] further determined that the rise in TBT enhances the export participation of enterprises while the promoting effect of SPS on their export participation is not significant.

Table 5.
Hausman test: fixed and random effect.

Coefficients	(b)	(B)	(b - B)	sqrt(diag(V_b-V_B))
	Fe	re	Difference	S.E.
logGDPjt	2.537	-0.726	3.263	.
logGDPsat	4.174	6.746	-2.572	2.932
logTBTsaj	1.464	2.002	-0.538	0.125
logSPS	0.048	0.675	-0.626	0.085
logREXRjt	3.120	-0.166	3.287	.
logInfla	-0.238	-0.589	0.351	0.141
logPROD	-2.611	-6.084	3.473	0.713
logPOPjt	-20.553	-0.490	-20.063	.
logIPIjt	-1.789	-1.624	-0.165	0.293
logEPIit	-0.639	-1.689	1.050	2.146
logREXRsat	0.736	2.185	-1.449	0.412
b =	Consistent under Ho and Ha and obtained from xtreg.			
B =	Inconsistent under Ha, efficient under Ho and obtained from xtreg.			
Test: Ho:	Difference in coefficients not systematic			
chi2(11)	(b-B)'[(V_b-V_B) ^(-1)] (b-B)			
	251.88			
Prob>chi2	0.0000			

The panel data underwent regression modeling using fixed and random effects approaches. Subsequently, the coefficients were subjected to the Hausman test to assess the consistency between the methodologies and determine if there was a systematic difference in the coefficients. The test assumes that any disparities in coefficients are not systematic. The result of the test yielded a chi-square value of 251.88 corresponding to a p-value of 0.0000 indicating acceptance at the 1% significance level.

The test rejects the null hypothesis as the p-value (Prob>chi2) is less than 5%.

H_0: Random effects would be consistent and efficient.

H_1: Random effects would be inconsistent.

Hence, the null hypothesis is dismissed indicating that the two models generated coefficients displaying consistent and systematic differences. The examination recommends opting for fixed effects (FE) as it signifies that country effects while existing in the dataset are associated with the explanatory variables and can be treated as constant; the estimators for fixed effects will remain dependable and effective. The utilization of the fixed effect model in the analysis is favoured over the random effect model as the latter does not contribute significantly with its coefficients deviating from those produced by the fixed effects model.

6. Conclusion and Recommendations

Utilizing panel data, this research investigates the impact of South African food safety regulations on orange exports to key Asian markets. The study employs the gravity model with STATA software to assess the influence of these regulations. The compliance efforts with SPS and TBT should be seen as an opportunity to enhance quality standards and market sophistication in orange exports to vital Asian nations rather than being viewed as a hindrance. Addressing TBT restrictions in South Africa necessitates coordinated global initiatives beyond the World Trade Organization (WTO) to secure additional financial and technical support. Additionally, leveraging marketing buyer channels can facilitate the entry of local orange exporters into Asian markets. The interaction between marketing buyer channels and local suppliers mirror typical arm's length transactions where both parties negotiate commercial contracts involving product price, quantity, quality, and delivery.

Moreover, progress in agriculture could aid underprivileged nations in fulfilling food safety standards. Enhancing the agricultural sector involves elevating land quality, upgrading irrigation infrastructure, and ensuring adequate access to essential resources like fertilizers. Advancing production technology is crucial for enhancing agricultural quality and yield. Specific technological breakthroughs could result in a prolonged and more consistent seasonal harvest, improved flavor and hygiene, and more standardized output. Regulating production timing, reducing risks and enabling producers to diversify their crop or livestock mix are potential benefits. Governments in developing countries should address credit market inefficiencies and ensure that farmers and businesses in the processed food sector enjoy fair and accessible financing opportunities to boost the agricultural sector and processed food industries.

It is important to acknowledge the data availability limitations reported during the period. Consequently, the data was not collected in the desired geographical region, in the desired years or from the specific population of interest. Additionally, some variables were initially included in the study. However, these variables were then excluded due to unavailability. The study focused on 10 Asian strategic markets. Therefore, the strategic markets can be expanded to cover the entire Asian continent for future study. This will help to determine the greater view of the competitiveness of South African oranges in that region. Assessment of the whole Asian region will play a key role in enhancing economic growth.

Secondly, the framework used in this study may be useful to analyze the competitiveness of any industry by considering the food safety standards imposed.

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