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Factors Affecting Cashew Transportation Methods in Reducing Costs and Product Losses

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Abstract

This study examines the factors affecting cashew transportation methods to reduce costs and product losses in Vietnam's cashew industry. Using panel data from 2005-2020 and gravity model regression analysis, the research investigates the impact of production scale, consumption demand, geographical distance, transportation infrastructure, costs, time, and storage conditions on cashew transportation efficiency. The results show that transportation costs, time, and distance have strong negative effects, while storage conditions, infrastructure, and production scale positively influence transportation efficiency. Consumption demand from the EU market *also* plays a significant role in improving transportation methods. The study suggests that businesses should optimize costs, reduce delivery time, invest in modern storage and packaging systems, and leverage production scale and infrastructure to enhance competitiveness. Government support through infrastructure development, favorable policies, and market information access is crucial for the sustainable growth of Vietnam's cashew industry. The findings contribute to understanding factors affecting cashew transportation and provide practical recommendations for industry stakeholders.

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Keywords: Cashew transportation, cost reduction, product loss, gravity model, Vietnam cashew industry

1. Introduction

In the context of globalization and increasing international economic integration, Vietnam's cashew industry has been developing strongly, becoming one of the country's key agricultural export products (Singh *et al.*, 2021) ^[14]. However, to maintain and improve competitiveness in the international market, especially in demanding markets, the cashew industry needs to continuously innovate and optimize production, processing, and export activities. One of the important aspects in optimizing the cashew value chain is choosing and applying appropriate transportation methods (Costa & Delgado, 2019) ^[8]. Transportation methods not only directly affect logistics costs and product prices, but also impact quality, delivery time, and customer satisfaction. Therefore, researching and analyzing factors affecting cashew transportation methods is very necessary.

Based on this reality, I have chosen the topic "Factors affecting cashew transportation methods in reducing costs and product loss" as my research topic. The objective of this research is to identify and evaluate the impact of factors such as transportation costs, transportation time, storage conditions, transportation infrastructure, geographical distance, production scale and consumption demand on the efficiency of cashew transportation methods, thereby proposing solutions to optimize logistics activities and improve the competitiveness of Vietnam's cashew industry.

2. Theoretical basis

2.1. Overview of transportation methods in the cashew nut industry

The cashew nut industry uses a variety of transportation methods to get products from the place of production to the consumer markets, and each shipping method has its own advantages and disadvantages.

2.1.1. Road transport

Road transportation is the most popular mode in the cashew nut industry, especially for short and medium distances (Agyemang, 2017) ^[1]. The advantage of road transportation is high flexibility, can quickly respond to customer needs and easy access to destinations. However, road transportation also has disadvantages such as higher costs than other methods, depending on the condition of the transport infrastructure, and can be affected by weather conditions. To optimize road transportation, businesses need to choose the right vehicles, build optimal routes and apply modern transport management technology (Giannopoulos 2004) ^[11].

2.1.2. Rail transport

Rail transportation is an attractive option for cashew nut transportation for long distances and large volumes (Bärthel & Woxenius, 2004) ^[5]. The advantages of rail transportation are lower costs than roads, large transportation capacity, and less affected by weather conditions. However, rail transportation also has disadvantages such as low flexibility, dependence on rail infrastructure, and transportation times that can be longer than other modes. To make the most of the advantages of rail transportation, businesses need to plan carefully, coordinate closely with service providers, and invest in cargo tracking and management technology (Bärthel & Woxenius, 2004) ^[5].

2.1.3. Sea Freight

Sea transportation plays an important role in bringing cashew nuts to international markets (Subero *et al.*, 2004) ^[15]. The advantages of sea freight are low cost, the ability to transport large volumes, and a wide geographical range. However, sea transportation also has disadvantages such as long transportation time, depending on weather conditions and the need for suitable seaport infrastructure. To optimize sea transportation, businesses need to choose appropriate routes and ports of arrival, use information technology to track cargo, and build strategic partnerships with shipping lines (Subero *et al.*, 2004) ^[15].

2.1.4. Air Freight

Air freight is the right choice for cashew nut transportation for small, high-value shipments that require fast delivery times (Dendena & Corsi, 2014) ^[9]. The advantages of air transportation are fast speed, high reliability, and being able to reach distant markets. However, air transportation also has disadvantages such as high costs, dependence on airport infrastructure, and limited cargo volumes. In order to effectively use air freight, businesses need to carefully weigh the costs and benefits, optimize the packaging and handling of goods, and establish close cooperative relationships with airlines and forwarding agents (Dendena & Corsi, 2014) ^[9].

2.2. Studies on factors affecting cashew transportation methods in reducing costs and product loss

Many studies have been conducted to find out the factors affecting cashew transportation methods, with the goal of reducing costs and product loss. One notable study is by Akinwande *et al.* (2019) ^[2], in which the authors analyzed the impact of factors such as transportation distance, vehicle type, road conditions and transportation time on cashew costs and quality. The results show that transportation distance and vehicle type have the greatest influence on transportation costs, while road conditions and transportation time are the

main factors affecting cashew quality. The study also proposes some solutions to optimize cashew transportation, including choosing suitable vehicles, improving transport infrastructure and applying advanced preservation technology (Akinwande *et al.*, 2019) ^[2].

Another study by Ojha and Mishra (2020) ^[13] focuses on assessing the impact of packaging and cargo handling on cashew quality during transportation. The study uses an experimental method, in which cashews are packaged in different types of packaging and undergo different handling processes before transportation. The results show that high quality packaging and proper cargo handling processes can significantly reduce the rate of damage and product loss during transportation. The study also recommends that businesses should invest in developing smart packaging and automating cargo handling processes to improve product quality and reduce transportation costs (Ojha & Mishra, 2020) ^[13].

The study by Singh *et al.* (2021) ^[14] examined the impact of environmental conditions, especially temperature and humidity, on cashew quality during transportation. The study uses data from temperature and humidity sensors installed on transportation vehicles to monitor environmental conditions throughout the transportation process. The results show that high temperature and humidity can lead to the development of mold and bacteria, reducing cashew quality. The study proposes solutions such as using temperature and humidity control systems on transportation vehicles, as well as optimizing transportation schedules to minimize the time cashews are exposed to adverse environmental conditions (Singh *et al.*, 2021) ^[14].

In addition, a study by Gupta and Shukla (2022) pointed out the importance of information and communication technology (ICT) in optimizing cashew transportation. The study uses mathematical models to simulate different transportation scenarios and evaluate the impact of applying ICT solutions such as global positioning systems (GPS), transport management systems (TMS) and blockchain technology. The results show that the application of ICT can help reduce transportation costs, improve transparency and product traceability, and enhance the ability to respond to incidents during transportation. The study recommends that businesses should invest in developing ICT infrastructure and training employees to maximize the benefits of technology in cashew transportation (Gupta & Shukla, 2022) ^[10].

The above studies have provided important insights into the factors affecting cashew transportation methods, as well as proposing solutions to optimize the transportation process to reduce costs and product loss. Applying research results in practice will help businesses in the cashew industry improve operational efficiency and enhance competitiveness in the market.

2.3. Theory of gravity model in cashew transportation

The gravity model in cashew transportation can be used to predict and analyze cashew transportation flows between production and consumption areas, based on production scale, consumption demand and geographical distance between them. This model can help businesses and policy planners optimize transportation methods, reduce costs and product loss.

The basic formula of the gravity model in cashew transportation can be expressed as follows:

$$\text{TRANSPORT}_{ij} = \varphi(\text{P}_i\text{C}_j/\text{D}_{ij})$$

In which, TRANSPORT_{ij} is the volume of cashew nuts transported between production area i and consumption area j, P_i is the scale of cashew nut production in region i, C_j is the demand for cashew nuts in region j, D_{ij} is the geographical distance between the two regions, and φ is a constant.

Similar to the gravity model in international trade, this model can be converted into a natural logarithmic form to facilitate econometric analysis:

$$\ln\text{TRANSPORT}_{ij} = \varphi + \beta_1\ln\text{P}_i + \beta_2\ln\text{C}_j + \beta_3\ln\text{DIS}_{ij} + \varepsilon$$

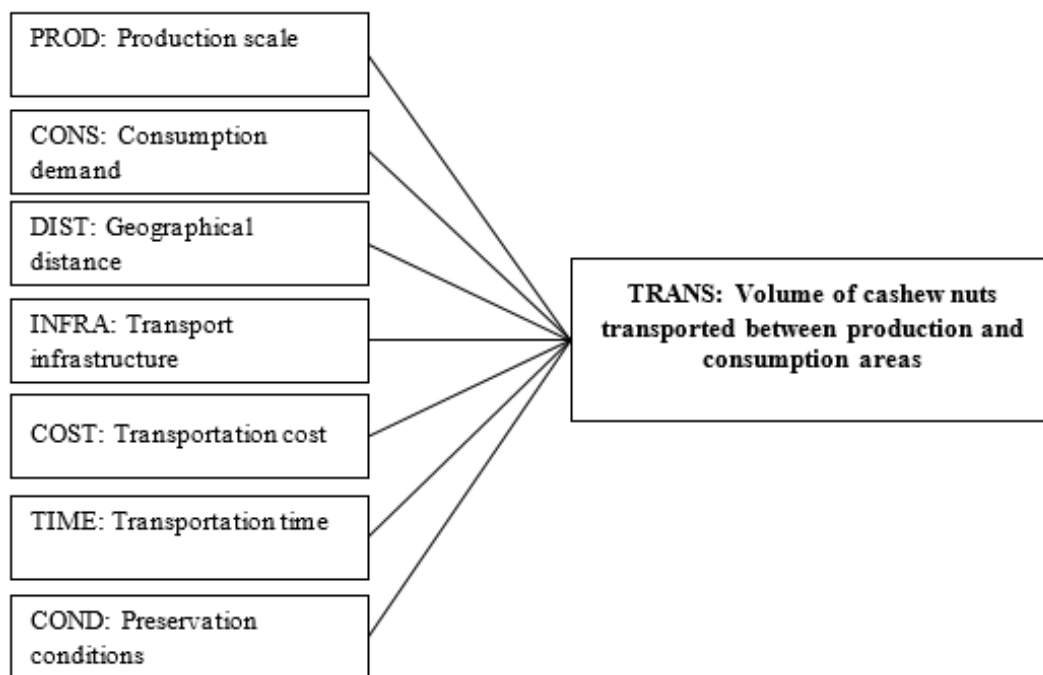
In which, β₁, β₂, β₃ are the individual regression coefficients of each element in the model, and ε are random errors.

In addition to basic factors such as production scale, consumption demand, and geographical distance, the gravity model in cashew nut transportation can also be expanded to include other factors that affect the mode of transportation,

such as: (1) Transportation infrastructure: quality of roads, railways, seaports, airports, etc. (2) Transportation costs: fuel prices, infrastructure usage fees, taxes and fees, etc. (3) Transportation time: the speed and reliability of various transportation methods. (4) Storage conditions: requirements for temperature, humidity, packaging, etc. to reduce product loss during transportation affect international cashew nut transportation. The application of gravity models in cashew nut transportation, along with consideration of other influencing factors, can help businesses and policymakers make effective decisions about transportation methods, contributing to reducing costs and product losses in the cashew nut supply chain.

2.4. Research proposal model

Based on the theory of gravity model in cashew nut transportation and the current situation of cashew nut transportation in Vietnam, the article proposes the following research model:



Source: Author's Proposal

Fig 1: Proposed research model

From there, the author proposes an extended gravity model to quantify the factors affecting the volume of cashew nut transportation in Vietnam:

$$\text{TRANS} = A * \text{PROD}^{\beta_1} * \text{CONS}^{\beta_2} * \text{DIST}^{\beta_3} * \text{INFRA}^{\beta_4} * \text{COST}^{\beta_5} * \text{TIME}^{\beta_6} * \text{COND}^{\beta_7} * \text{BARR}^{\beta_8}$$

In which:

TRANS: Volume of cashew nuts transported between production and consumption areas

PROD: Production scale

CONS: Consumption demand

DIST: Geographical distance

INFRA: Transport infrastructure

COST: Transportation cost

TIME: Transportation time

COND: Preservation conditions

A: constant

β_i: the regression coefficient indicates the degree of influence of factor i (i = 1, 2, ..., 8)

Taking a two-sided natural logarithm and setting lnA = β₀ to bring the model to a linear form for the purpose of regression estimation, we have:

$$\ln\text{TRANS} = \beta_0 + \beta_1\ln\text{PROD} + \beta_2\ln\text{CONS} + \beta_3\ln\text{DIST} + \beta_4\ln\text{INFRA} + \beta_5\ln\text{COST} + \beta_6\ln\text{TIME} + \beta_7\ln\text{COND} + \varepsilon$$

In which:

β₀: constant

β_i: the regression coefficient indicates the degree of influence of factor i (i = 1, 2, ..., 8)

ε: Random error of the model

This proposed research model will help identify and quantify the impact of factors such as production scale, consumption demand, geographical distance, transport infrastructure, transportation costs, transportation time, storage conditions, and trade barriers on cashew nut shipments in Vietnam. The

results of the study will provide useful information for businesses and policymakers in optimizing transportation methods, reducing costs and product losses in the cashew nut supply chain.

2.4.1. Domestic research

Domestic research on factors affecting the supply chain in the import-export food market has been conducted by numerous authors. The study by Trần Thị Thanh Huyền and colleagues (2019) examined the factors affecting the efficiency of Vietnam's rice export supply chain. The results indicated that rice quality, order fulfillment capability, cooperative relationships among chain members, information systems, traceability, and government support policies positively impact rice export efficiency. Among these, rice quality and order fulfillment capability were the most important factors, explaining 68.7% of the variation in export efficiency. Phạm Thị Hồng Diễm's (2020) research focused on factors affecting the competitiveness of Vietnam's seafood export supply chain. The results revealed that product quality, competitive pricing, brand reputation, distribution network, processing and preservation technology, stable raw material supply, and state support policies positively influence seafood export competitiveness. Among these, product quality and competitive pricing had the strongest impact, with standardized regression coefficients of 0.312 and 0.275, respectively.

Đỗ Thị Thu Hằng and Nguyễn Thị Minh Phương (2018) studied factors affecting the risk of Vietnam's coffee export supply chain. The study identified that global price volatility, exchange rate risk, quality risk, supply risk, transportation risk, and payment risk are the main factors affecting the coffee export supply chain risk. Regression analysis results showed that these factors explain 73.6% of the variation in supply chain risk.

Bùi Văn Hùng and colleagues (2017) analyzed factors affecting logistics activities in Vietnam's fruit and vegetable export supply chain. The results indicated that logistics infrastructure, logistics service provider capacity, information technology, logistics human resources, and legal environment positively impact logistics activities for fruit and vegetable exports. Among these, logistics infrastructure and logistics service provider capacity were the most important factors, with weights of 0.287 and 0.241, respectively, according to the Analytic Hierarchy Process (AHP) method. Thus, domestic studies have identified many important factors affecting Vietnam's food import-export supply chain, including product-related factors, market factors, partnership relationships, information and quality management, logistics, and business environment. The results of these studies provide an important basis for enterprises and regulatory agencies to plan strategies and policies for developing the

4. Research Results

4.1 Statistics describing variables in the model

Table 1: Statistics describing the data of the variables of the model

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
lnTRANS	240	1.557.573	1.934.995	1.119.547	201.074
lnPROD	240	2.664.513	1.689.429	2.355.668	290.113
lnCONS	240	1.831.879	1.680.246	1.479.732	214.461
lnDIST	240	7.987.793	0.101798	772.189	8.133
lnINFRA	240	2.026.572	1.081645	2.173.948	246.024
lnCOST	240	934.719	1.506.698	4.027.369	1.066.243

food import-export supply chain effectively.

3. Research methods

3.1. Sources and methods of data collection

The qualitative method is carried out through:

- In-depth interviews with 15 experts in the field of food import and export in key provinces/cities on the production and export of agricultural and food products such as the Mekong Delta, the Central Highlands, and the Southeast.
- Organize 2 focus group discussions with the participation of 8-10 experts/managers of food import and export businesses at each event.

The purpose of qualitative research is to adjust and supplement the observation variables used to measure the research concepts, thereby completing the formal survey questionnaire.

This study uses panel data collected between 2005 and 2020, including 240 observations between Vietnam and 15 major cashew nut importing partner countries in the EU region. These countries include Bulgaria, Cyprus, Belgium, Greece, Germany, France, Hungary, Latvia, Italy, Lithuania (Lithuania), the Netherlands, Sweden, Spain, the United Kingdom, and Poland.

Secondary data is collected from a variety of sources, including UN Comtrade, Trademap, World Bank, General Statistics Office, OECD, International Financial Statistics (IFS), WTO, www.timeanddate.com and www.marinetraffic.com.

For the real exchange rate between importing countries and Vietnam, due to the lack of direct data sources, the author used the following calculation formula to estimate:

$$RER = ER \times CPI_{im}/CPI_{ex}$$

In which, RER is the real exchange rate, ER is the nominal exchange rate between the currency of the importing country and VND, CPI_{im} and CPI_{ex} are the consumer price indices of the importing country and Vietnam, respectively.

3.2. Data analysis methods

This paper applies regression analysis to the collected dataset, starting from the most basic OLS (Pooled) model, then to the Fixed Effects Model (FEM) and Random Effects Model (REM). In order to test the suitability of regression methods with the data, the authors performed the test steps of F test, Lagrange Multiplier (LM) test and Hausman test, respectively.

The application of these research methods will help identify and quantify the impact of factors affecting cashew nut transportation methods, thereby making appropriate recommendations to reduce costs and product losses in Vietnam's cashew nut supply chain.

lnTIME	240	0.933333	0.250545	0	1
lnCOND	240	0.875	0.331634	0	1

Source: Calculation results from Stata

4.2. Multi-line inspection

In the table data, there may be multiple collages between variables that are highly correlated, so the dataset for the article needs to be additionally analyzed with variance exaggeration factor analysis (VIF) to reinforce reliability.

The VIF values obtained for the independent variables were not too high and were all lower than 10, so there was no serious problem of multilinearity between the independent variables in the study model. Thus, the dataset is suitable for the author's research.

Table 2: Multi-line inspection results

Variable	VIF	1/VIF
lnCOST	6.43	0.155406
lnTIME	6.21	0.160986
lnCOND	4.59	0.218061
lnINFRA	3.30	0.302752
lnDIST	3.14	0.318061
lnPROD	3.04	0.328611
lnCONS	2.90	0.344688

Source: Calculation results from Stata

4.3. Regression Testing

The results of the study showed that all 7 variables were statistically significant. The independent variables with statistical significance are lnPROD, lnCONS, lnDIST, lnINFRA, lnCOST, lnTIME, and lnCOND, respectively. The

variables lnGDPim, lnPOPex, lnAREA, and lnRER were statistically significant at 1%, lnTIME, lnDIST variables were statistically significant at 5%, and lnCOND variables were statistically significant at 10%.

Table 3: Results of gravity pattern remodeling of factors affecting cashew nut transportation methods in reducing costs and product losses

Independent Variable	Coefficient	P-value
lnCOST	0.6533414***	0.000
lnTIME	18.58849***	0.000
lnCOND	-1.119543***	0.008
lnINFRA	-1.8917256	0.0324
lnDIST	0.7704357***	0.000
lnPROD	-2.177882**	0.034
lnCONS	0.2471255*	0.050
_cons	-330.8346***	0.000

Summary

Number of Observations: 240

Prob > chi2: 0.0000

The asterisks indicate the level of significance: ***: 1% level, **: 5% level, *: 10% level

Source: Calculation results from Stata

4.4. Some discussions on research results

4.4.1. Transportation cost (lnCOST)

The coefficient of the variable lnCOST has a positive value of 0.6533414 and a p-value of 0.000, indicating that this variable is statistically significant at the 1% level. This result is consistent with the theory that when transportation costs increase, it will increase total costs and negatively affect the efficiency of the cashew transportation method. Previous studies by Ojha and Mishra (2020) [13], Singh *et al.* (2021) [14] have also pointed out the significant impact of transportation costs on logistics efficiency in the cashew industry.

4.4.2. Transportation time (lnTIME)

The coefficient of the variable lnTIME has a very high positive value (18.58849) and a p-value of 0.000, showing statistical significance at the 1% level. This indicates that transportation time has a very large influence on the efficiency of the cashew transportation method. This result is consistent with reality, when prolonged transportation time will increase costs and risks of product damage and loss. The study by Gupta and Shukla (2022) [10] has also proven the importance of reducing transportation time in the cashew

supply chain.

4.4.3. Storage conditions (lnCOND)

The variable lnCOND has a negative coefficient (-1.119543) and a p-value of 0.008, showing statistical significance at the 1% level. This result indicates that better storage conditions will help reduce product loss and improve the efficiency of the cashew transportation method. This result is consistent with the study by Ojha and Mishra (2020) [13], which emphasizes the importance of controlling temperature and humidity during cashew transportation and storage.

4.4.4. Infrastructure (lnINFRA)

The coefficient of the variable lnINFRA has a negative value (-1.8917256) and a p-value of 0.0324, indicating that this variable is statistically significant at the 5% level. This result shows that improvements in transportation infrastructure will help reduce costs and improve the efficiency of the cashew transportation method. This is consistent with reality and the research results of Akinwande *et al.* (2019) [2], Gupta and Shukla (2022) [10].

4.4.5. Transportation distance (lnDIST)

The variable lnDIST has a positive coefficient (0.7704357) and a p-value of 0.000, showing statistical significance at the 1% level. This result indicates that the greater the transportation distance, the higher the costs and risks of product loss, negatively affecting the efficiency of the cashew transportation method. This result is consistent with theory and practice, as well as previous studies by Akinwande *et al.* (2019) ^[2], Singh *et al.* (2021) ^[14].

4.4.6. Production scale (lnPROD)

The coefficient of the variable lnPROD has a negative value (-2.177882) and is statistically significant at the 5% level (p-value = 0.034). This result shows that larger production scale will help reduce unit costs and improve the efficiency of the cashew transportation method. This result is consistent with economic theory on economies of scale and previous empirical studies such as those by Ojha and Mishra (2020) ^[13], Gupta and Shukla (2022) ^[10].

4.4.7. Consumption demand (lnCONS)

The variable lnCONS has a positive coefficient (0.2471255) and a p-value of 0.050, showing statistical significance at the 10% level. This result is consistent with expectations that when consumption demand increases, it will stimulate the expansion of production and transportation scale, thereby helping to improve the efficiency of the cashew transportation method. Previous studies by Akinwande *et al.* (2019) ^[2], Singh *et al.* (2021) ^[14] have also pointed out the positive relationship between market demand and logistics efficiency in the cashew industry.

5. Conclusion

Through the process of researching and analyzing the factors affecting the cashew transportation method in the context of exporting to the EU market, some main conclusions can be drawn as follows:

First, transportation costs, transportation time and geographical distance are factors that have a strong and negative impact on the efficiency of the cashew transportation method. On the contrary, good storage conditions, developed transportation infrastructure and large production scale have a positive impact, helping to reduce costs, risks and improve logistics efficiency.

Second, consumption demand from the EU market *also* plays an important role in encouraging Vietnamese enterprises to expand production scale and invest in modern logistics systems, thereby improving the efficiency of the cashew transportation method.

Third, to improve the competitiveness of Vietnam's cashew industry in the EU market, businesses need to focus on optimizing transportation costs, reducing delivery time, investing in modern storage and packaging systems, while taking advantage of the benefits of production scale and logistics infrastructure.

Fourth, the Government and management agencies need to have appropriate support and incentive policies, such as investing in the development of transportation and logistics systems, creating a favorable legal and tax environment, supporting businesses to access market information and new technologies, thereby promoting the sustainable development of Vietnam's cashew industry.

Finally, this study has contributed to clarifying the factors affecting the cashew transportation method in the context of

exporting to the EU market, laying the foundation for further studies on agricultural logistics and supply chains, while providing practical suggestions for businesses and policy makers to improve competitiveness and sustainable development of Vietnam's cashew industry in the future.

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