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The Effects of Increased Distance Travel on the Operating Costs of Freight Truck Vehicles

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ABSTRACT

Transportation industry is an important part of most countries' economies with significant effects on productivity and social welfare. However, refrigeration has dramatically altered global food transportation efficiencies in the cold supply chain. Hence, a key factor to optimize transportation is by lowering operational costs, with distance travel having a considerable impact. The paper examines how the operational costs of different truck classes is influenced by the distance travelled. The operating cost equation was utilized to make a comparison between vehicle operating costs and to assess how these costs change in relation to travel distance. The equation consists of influential parameters such as fuel cost, driver wage, and maintenance cost of a vehicle. The result showed that the operating cost rate varies among trucks of different classes. According to the results of the equation and effective parameter analysis, 18-ton trucks had the highest cost, followed by 5-ton trucks. This is due to fact that the cost is influenced by factors of travel distance, tolls, and fuel consumption. Furthermore, based on transportation costs, a green practice framework can be constructed to reduce truck costs for each delivery while reducing CO_2 *emissions to the environment. By taking into account transportation cost factors in the framework of green practices, effective and practical information can be generated such as product delivery schedules to customers and better routes to improve business performance. Finally, effective transportation management can improve inventory flow by enhancing warehouse efficiency, reducing overall lead time, and saving on storage costs.*

Keywords: Refrigerated Transportation; Trucks Operating Costs; Cold Supply Chain; Case Study; Linear Regression Equations

INTRODUCTION

The food transportation system is a way of delivering food to locations that may be far away and it is expected that the storage of transportation is kept at low temperature conditions (-4ºC to 4ºC) to extend the shelf life and maintain the quality of the food (Adekomaya et al. 2016).

For perishable food that has shorter life cycle, a cold chain transportation systems is highly required (Kuo & Chen 2010). Transportation systems, such as cold chains for product supply and delivery, require certain temperature controls (Ramundo et al. 2016). Hence, each vehicle features chilled containers with insulation and refrigeration equipment incorporated into its frame. The equipments are often powered by an external power supply on board the ship or port, or by a generator on a road vehicle. Insulated containers for refrigerated foods can be fitted with plug-in refrigeration units or directly attached to an air-handling system in the hold or at the docks. Containers put in insulated holds and connected to the vehicle's refrigeration system obtain the best temperature control (James 2019).

However, interruptions in the temperature-controlled cold chain are a typical issue while delivering and storing food. Transportation disruptions are delays in deliveries, causing deviations from the stipulated delivery schedule and affecting the product quality (Manzini & Accorsi 2013; Zulkefly et al. 2021). The study by Romotowska et al. (2017) showed that the temperature changes during shipping had a significant impact on the quality and stability of frozen mackerel. Temperature fluctuations during shipping resulted in more progressive lipid oxidation of mackerel compared to mackerel maintained at stable temperatures. The results also showed that lipid degeneration caused by temperature manipulation during transit cannot be prevented by suitable storage settings after the damage has occurred.

Furthermore, according to the findings of Gligor et al. (2018), there are numerous barriers in implementing cold chain in transportation system, which is high installation and operations costs. This is due to the fact that vehicles utilise fuel during transportation, and refrigeration equipment also consumes energy. Therefore, energy costs include two parts, the cost of vehicle fuel and the cost of refrigeration equipment fuel (Xiao et al. 2012). According to Hooper and Murray (2018), the vehicle costs include fuel, tolls and maintenance, while driver costs are wages and benefits. Many previous researchers had studied the total cost of transportation system. For example, Gohari et al. (2018) studied the impact of fuel prices on transportation vehicle operating costs. Meanwhile, Levinson et al. (2005) studied the operational expenses of commercial vehicles based on the truckloads. Despite the fact that most studies on transportation costs have concentrated on the travel distance of the truck with the type of trucks used, few studies have focused on the travel distance of the truck with the type of trucks used. As a result, this paper will investigate the relationship between transportation system cost and travel distance based on the type of vehicles used for food delivery.

There are numerous methods for determining truck cost per km, each employing unique methodologies and models to evaluate the variable expenses associated with truck operations. Fuels, repair and maintenance, tires, depreciation, and labour chargers are all important elements in calculating the operational cost per kilometre (Levinson et al. 2005**.**

The costs of supply chain are influenced by logistics, making transportation a crucial part in every supply chain planning (Song et al. 2014**).** Optimization of cost, time and storage conditions of fresh food during transportation has a significant practical value and has received significant attention in the research (Nakandala et al. 2016). The overall cost includes transportation, cooling, and depreciation costs (Akkerman et al. 2010; Amorim et al. 2014). The transportation cost accounts for all expenses involved with transportation at each point of the route; the cooling cost comprises all cooling-related chargers once the cooling system is started; and the devalued cost covers all costs associated with product devaluation (Nakandala et al. 2016).

The cost of gasoline, wages, labour, depreciation, maintenance, the cost of tyres and spare parts, the cost of getting various permissions, the cost of insurance, and indirect costs must all be addressed in order to reduce transportation costs (Burda 2015). In addition, Wojuade & Oladosu (2020) also stated that fuel, maintenance, driver compensation, and training expenses make up the entire truck operating cost.

It has been noted that the possibilities of minimising transportation losses will be able to lower product prices, enhance farmers' financial circumstances, decrease farmers' reliance on high-interest loans from agents, boost employment, and decrease food waste (Raut & Gardas 2018). For a trip with multiple pickup points, route selection is one of the major decisions (Nakandala et al. 2016b). The industry faces a challenge in maintaining a consistent temperature during long-distance transportation of frozen food goods (Romotowska et al. 2017).

Costs and profit margins are influenced by a vector of explanatory variables that can be divided into five groups: path, economy of the origin and destination markets, features of the mode of transportation, transportation market, and firm. The gravity approach, which focuses on factors linked to the route (mostly distance) and the economics of the origin and destination markets of the transported commodities, forms the basis for a substantial portion of the selection of variables used in the first transport cost model (Camisón et al. 2020). That is why by examining the transport route and distance during delivery, we can build a model to reduce transport cost. The model enables the calculation of the cost of the service for each route by combining the determining variables of transport costs with route level.

METHODOLOGY

A comprehensive review of the current literature was undertaken in order to structure the open-ended questionnaire. This was followed by a preliminary test involving two senior managers from the case study organisations: the Deputy Director of Design and Development from the first organisations and the Deputy General Manager of Supply Chain from the second organisation. On-site interviews and observations were conducted, and the questionnaire was distributed to participants prior to each interview to aid in preparation and data collection. Respondents were also given information about the study's objectives. Data was gathered through interviews, first hand observations, documentation, and archive materials. While the majority of the data was qualitative in nature, quantitative data (such as fill rate, rejection rate, and inventory ratio) was also acquired to support the findings (Gorane & Kant 2016).

The research method used was the case studies with two frozen food manufacturing industries, through interviews and observations in the transportation unit. The case study was developed through interviews. This is due to the fact that interviews can serve as a basis for a case study aimed at identify key concerns that can then be formulated into questionnaire items (Ruslin et al. 2022). The interviews were conducted in transportation managers and supervisors. The companies provided the necessary data spanning the period January 2020 to December 2020. This time span would allow the study to establish a large enough pattern to identify cost differences and their impact on transportation costs. Figure 1 depicts the research methodology flow.

For the analysis, the data set to be evaluated was provided in Excel and used to obtain results from linear regression. During the interview acceptance process, the corporation identified secrecy as a critical consideration. As a result, a non-disclosure agreement was drafted between the company and the other parties to protect the information throughout the process. The data was obtained directly from enterprise systems and converted to Excel, assuring data integrity and source validation. The model generated by (Gohari et al. 2018) that used total cost as a dependent variable and fuel price, fuel consumption, travel distance, wage and maintenance as independent variables.

$$TC = \left[\left(F_p \times F_c \times T_d\right) + \left(W_a \times T_t\right) + \left(M_a \times T_d\right)\right] \times \left({}^{N_c}/_{C_v}\right) \quad (1)$$

Where TC, F_p, F_c and T_d are the respective transport cost (RM), fuel price (RM/liter), and fuel consumption (liter/km), and travel distance (km). W_a, T_t, M_a, Nc and C_v represent the wage (RM/h), travel time (h), maintenance (RM/km), the number of containers, and vehicle capacity (TEU). The fuel price, wage, and travel time are all fixed.

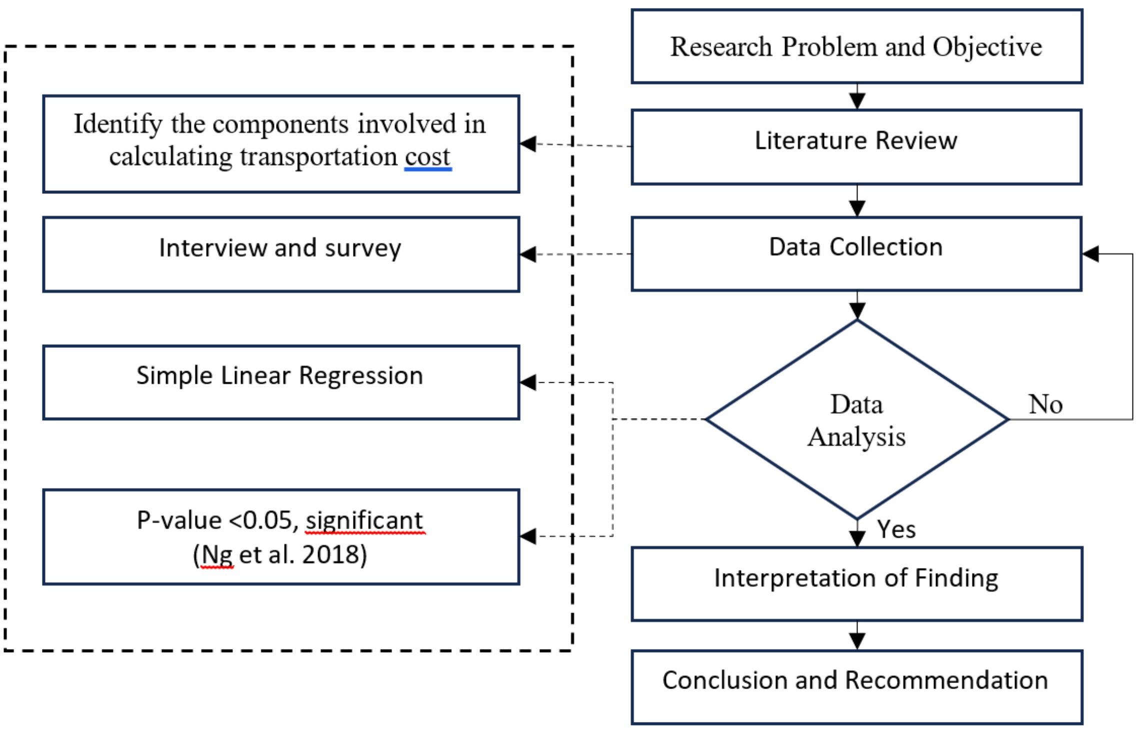

FIGURE 1. Flowchart of Research Methods

RESULT AND DISCUSSION

The study was conducted at two frozen food manufacturing companies named as Company A and Company B. Both companies that were used as research options are located around the Selangor area. Company A specialises in the production of frozen perishable food items, with a particular focus on products produced from beef and chicken. Company A has been nurtured as a family-owned company for 38 years. In addition of having a workforce of more than 250 people and an annual revenue of more than RM 50 million, it clearly qualifies Company A as a large type of company (SME Corp Malaysia 2022).

Similarly, Company B serves as a supplier of frozen perishable food products across Malaysia. With a four-decade operational history, Company B continues to operate. Employing a workforce of 80 employees and generating an annual revenue ranging from RM 15 million to RM 50 million, it is evident that Company B fits the description of a medium-sized company (SME Corp Malaysia 2022).

Figure 2 and Figure 3 depict the costs of operation costs associated with the truck's distance travelled. This expenses include the total fuel usage, driver wages, and truck maintenance. This analysis focuses on the total costs of truck operations against the distance travelled during delivery. As shown in figure 2 and 3, the operating cost of an 18-ton truck is 2.5 times that of a 5-ton truck for the same travelled distance. The difference exists because larger-capacity vehicles have proven inefficient for delivery products over short distances. As a results, larger-capacity vehicles have higher fuel consumption rates (Carlan et al. 2019).

The equation shown in Figure 2 and Figure 3 represents a linear relationship between truck costs and the distance travelled during delivery for Company A and B. Through linear regression analysis, the total cost of truck operations can be explained, controlled and predicted when the value of the travel distance is known. Based on both linear regression analysis, the total cost of the truck increases linearly as the distance travelled increases. The p-value for a 5 ton truck is 0.01 and for an 18 ton truck is 0.04. According to Ng et al. (2018) the p-value indicates if the variable has a significant effect on the target, which in this case is the truck's operational cost. If the p-value for the variable (travel distance) equals or exceeds 0.005, it is regarded to have no significant impact on transportation costs. However, if the p-value is less than 0.05, the variable (travel distance) is considered to have a significant effect on transportation costs. Therefore, since the p-values for both 5 ton and 18 ton trucks are lower than 0.05, then, it shows that the travel distance has a significant impact on the operating cost of trucks in company A.

COMPANY A

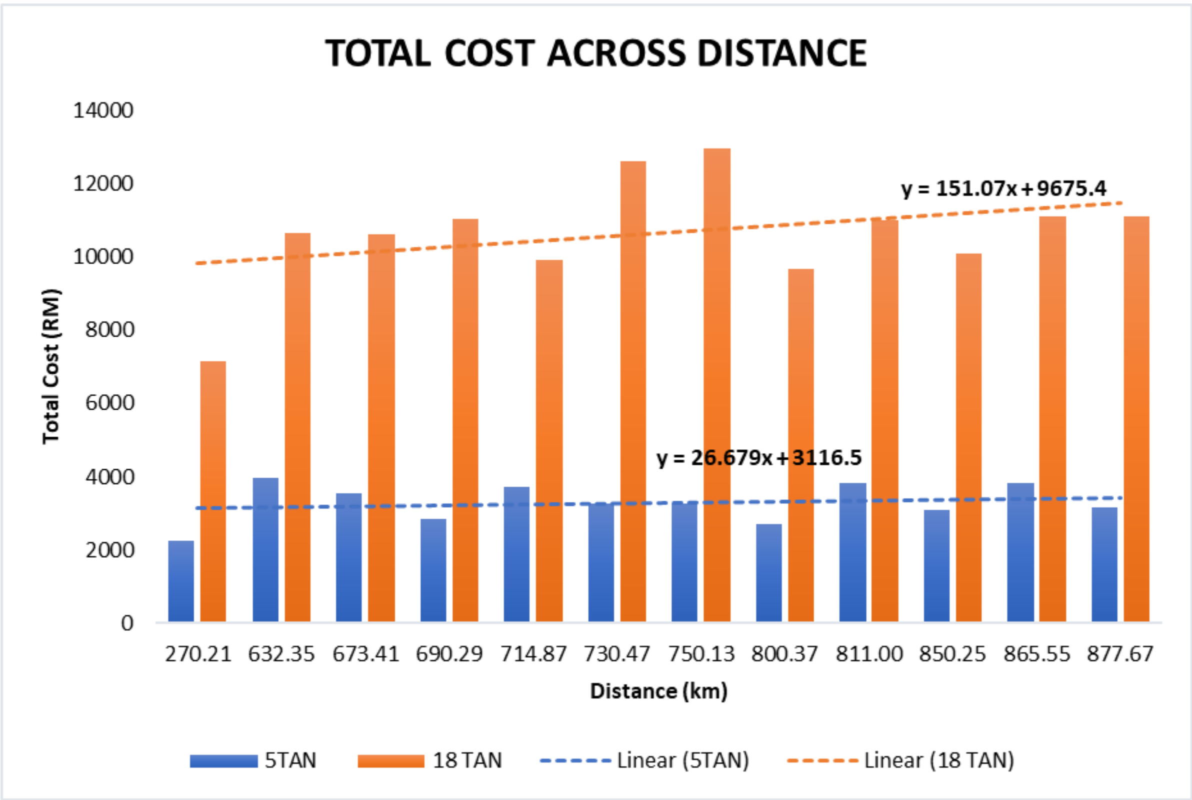

FIGURE 2. Linear Regression Analysis for 5 and 18 Ton Trucks in Company A

COMPANY B

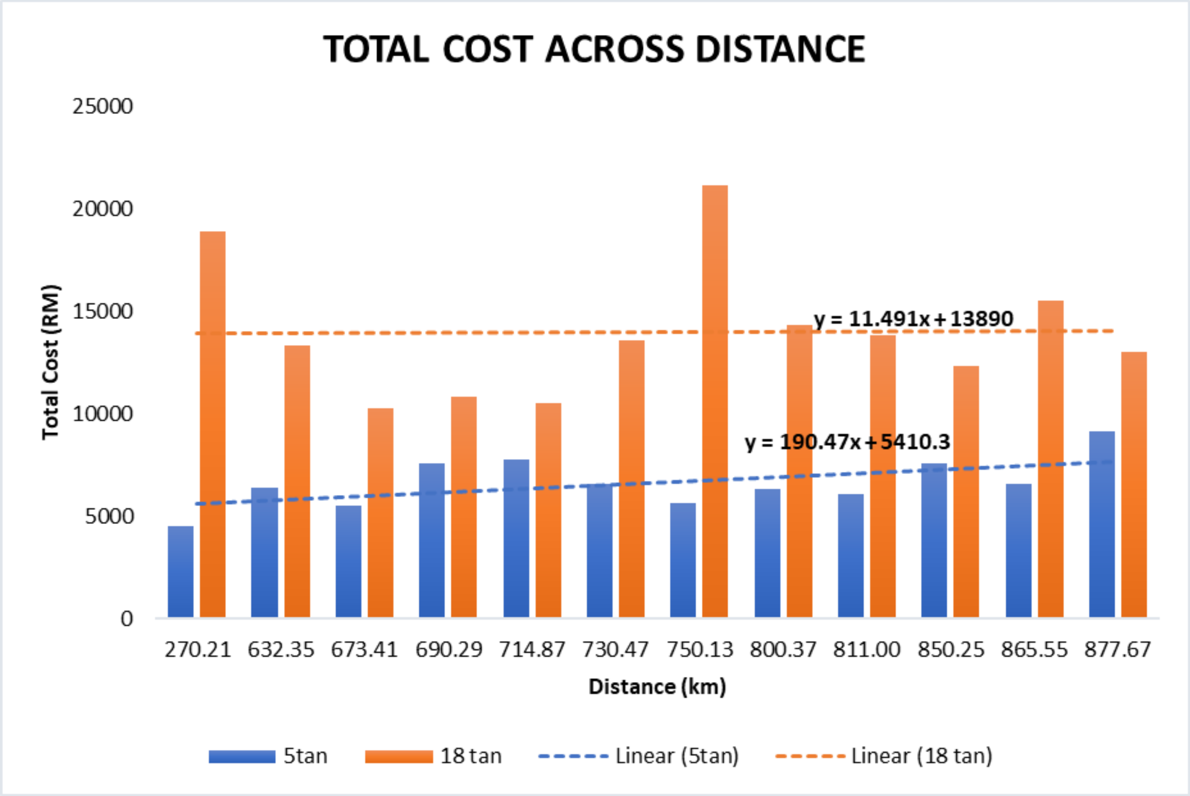

FIGURE 3. Linear Regression Analysis for 5 and 18 Ton Trucks in Company B

Linear regression analysis for company B shows that 5 ton trucks and 18 ton trucks have a linear relationship between the total operating cost of the truck and also the distance travelled. The p-value for a 5 ton truck is 0.02 and for an 18 ton truck is 0.01. since the p-value for both types of trucks, 5 tons and 18 tons is smaller than 0.05, then, the equation of the relationship between the operating cost of the lorry and the distance travelled is accepted. When the travel distance increases, the total operating cost of the lorry will also increase according to the equation as shown in Figure 3.

The results of the linear regression analysis of the operation cost of different classes of trucks are not the same. A comparison of the results from the equations and effective parameters considered shows that the 18 ton truck has the highest cost followed by the 5 ton truck. This is because the cost is affected by travel distance, tolls and fuel consumption (Gohari et al. 2018). Next, based on transportation costs, a green practice framework can be built to reduce truck operation costs for each delivery while also reducing CO_2 emissions to the environment. By taking into account the transportation cost factor within the framework of green practices, effective and practical information can be produced such as product delivery schedules to customers and better routes to improve business performance (Carlan et al. 2019). This is supported by Lu et al. (2021) research, which found that transportation costs are an important factor in cold chain transportation route optimisation. Finally, effective transportation management can improve inventory flow by increasing warehouse efficiency, reducing the time it takes for products to reach customers and saving on storage costs (Fan et al. 2021).

CONCLUSION

The operating cost equation of freight transport was utilised in this paper to estimate freight container transport costs as distance increased for trucks of different classes. The following conclusions can be drawn based on the operational cost equation and assumptions addressed in this study. The 16-ton truck was the most expensive, with a cost per TEU around 2.5 times that of the 5-ton truck. Moreover, across all truck classifications, there was a linear relationship between the distance travelled and the operational cost. Although 5-ton trucks yield the most revenue per kilometre than 18-ton trucks, they also have higher costs for a long distance travelled. This implies that 18-ton trucks are better suited for long distances (Leslie & Murray 2022). As a result, it is crucial to develop an optimised transportation route and use a suitable vehicle type for product delivery. This is critical for lowering the costs associated with cold chain transportation (Liu et al. 2021).

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DECLARATION OF COMPETING INTEREST

None

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