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# Measurement model for national logistics cost of Indonesia

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ABSTRACT

National logistics costs are a crucial indicator for nations to monitor and evaluate the efficiency of their logistics activities. They also serve as an essential foundation for economic growth. A lack of data is the primary challenge in measuring national logistics costs. To accurately assess these costs, countries must have reliable statistics on transportation and inventory. Without such data, estimating logistics costs becomes highly challenging, and the results are often unreliable. This research aims to develop a national logistics cost model for Indonesia. The key contribution of this study is that it represents the first effort to create a logistics cost model specifically for Indonesia. The model is developed based on the frameworks used in the United States of America, the Republic of Korea, and South Africa, adjusted to fit the data available in Indonesia. It comprises three main components: transportation costs, inventory handling costs, and administrative costs. Transportation and inventory handling costs are modeled based on the approach used in the Republic of Korea, while administrative costs are based on the model from the United States of America. This study introduces 25 calculation scenarios, and based on the selected scenario, the average national logistics cost of Indonesia from 2004 to 2010 is found to be 27.94% of GDP.

## 1. Introduction

Logistics is one of the important things for developing countries in facing free trade. Indonesia is one of the developing countries in the world which must also face free trade with the level of competition that is getting intense every day. This intense competition causes the logistics environment of a country becoming a major consideration for companies to make decisions about which country to go to, which supplier to choose, and the market to enter [1]. Indonesia does not have its own national logistics cost model to measure its national logistics cost whereas that information is important. Measuring national logistics costs is important because logistics costs are an appropriate indicator for the past and the future. The measurement of national logistics costs supports the making of national policies and operational targets as well as capital resources, such as transportation infrastructure investment. The measurement of national logistics costs provides a performance of measure and makes the way for corrective action.

Measuring national logistics costs is an appropriate indicator for monitoring and national logistics. The importance of logistics costs increases when it is also known that the efficiency of infrastructure logistics activities is important in economic growth [2], [3], [4], [5]. Measuring logistics costs at national level is more complex than at the company level, although measuring logistics costs at the company level is complex [6], [3], [7], [8]. Two things are significant in measuring logistics costs. They are the complexity of the surface process, namely the overall costs of the flow of material and information within the company and complexity of calculating depreciation, which is calculating the reduced value of all property and equipment related to logistics activities [9], [10], [11], [12].

Given the above complexities, it is either very difficult or impossible to measure logistics costs at the national level accurately. What can be achieved is an estimation of national logistics costs and the efforts should be focused on reducing the error in the results of this estimation. To estimate national logistics costs, countries must have reliable statistics in transportation and inventory parts. Without this data, estimating logistics costs is very difficult and the results are not reliable [3], [13].

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Several countries have succeeded in measuring their national logistics costs by using the basic model of national logistics costs adjusted to the availability of data in their countries. For example, United States of America, Republic of Korea, and South Africa. The three countries use national logistics costs models that are adjusted to the availability of data in their country, so that there are different models for measuring the national logistics costs in each country. Indonesia cannot directly use the national logistics cost measurement United States of America, Republic of Korea, and South Africa because surely the availability of data in Indonesia is different from those of the three countries.

In estimating their land transportation costs, United States of America and Republic of Korea use different approaches. United States of America estimates the land transportation costs based on the operating costs of trucks between cities and within cities, because the data are available and can be calculated every year. The Republic of Korea estimates the land transportation costs which are previously divided into two categories, namely public land transportation and private land transportation. Public land transportation costs are estimated based on the revenues of companies operating in the land transportation sector, while private land transportation costs are estimated based on the total operating costs of trucks. It can be seen from this element alone, that United States of America and Republic of Kore have different approaches of estimating the costs because they are adjusted to the availability of data in their countries [14].

Logistics costs indicator is a popular performance indicator, though the measurement methodology has not been standardized [15]. Moreover, there is no guideline regarding which indicator to use when measuring the logistics costs. Different methods use different categories for calculating logistics costs with a little disparity. Nevertheless, most of these methods consider transport, inventory, and administration costs as their categories [3].

According to [16], categories of logistics costs are transportation, inventory holding, administration, customs, risk and damage, handling and packaging. Quality and performance of logistics systems are different among countries. Ref [3] described some important factors affecting logistics costs. They are geographical situation, logistics infrastructures, human resource, administration, technology, political and economic stability, business legal rules, rate of interest, energy price. Logistics costs of a country are presented in percentage of gross domestic product (GDP). It means that logistics costs are equal to X% of GDP [3]. GDP is the total value of final goods and services produced for consumption within a country's boundaries in a given time of period (usually a year).

The first published methodology for assessing logistical costs was introduced by Heskett et al. in 1973 [3]. They applied their methodology to estimate the total logistics costs of the United States of America. Their approach identified four types of commercial activities: transportation, inventory, warehousing, and order processing. Annual logistics costs were calculated as the sum of these categories [17].

Building on this methodology, Robert Delaney, under the sponsorship of Cass Information Systems and ProLogis, estimated annual logistical expenditures for the U.S. economy. Delaney focused on three key categories for estimating logistics costs: inventory carrying costs, transportation costs, and administrative costs. These categories have been consistently used in the methodology for calculating the logistics costs of the U.S. since 1973. This approach is referred to as the CASS methodology, named after Cass Logistics Incorporated, the institution responsible for calculating the logistics costs of the United States [17].

The Republic of Korea has been particularly focused on addressing logistics challenges since the 1980s. The Korea Transport Institute is the organization responsible for developing the methodology and calculating the logistics costs of the Republic of Korea. The categories used in their calculations include transportation costs, inventory holding costs, packing costs, unloading and loading costs, information costs, and administration costs.

In South Africa, the first logistics cost calculation was conducted in 2004. The methodology was developed and implemented by the Department of Logistics at the University of Stellenbosch. Before calculating logistics costs, the concept of throughput was defined. Throughput referred to the total amount of goods transported and stored, expressed in physical units such as tonnage or volume. It included goods from both the primary sector (mining and agriculture) and the secondary sector (manufacturing and processing). South Africa employed two methodologies to calculate logistics costs: the top-down and bottom-up approaches, which were used in parallel to provide comprehensive results [18].

Considering the lack of data in Indonesia related to logistics activities, measuring of Indonesian logistics costs is very difficult. Ministry of Transportation that regulates transportation in Indonesia is not entirely reliable in the availability of data of transportation. Central Bureau of Statistics of Indonesia also cannot provide the required data. If to measure the national logistics cost of Indonesia, a special survey needs to be conducted to collect the data, then the process of measuring the national logistics cost would be very inefficient. It is because the survey would be conducted annually for national logistics cost needs to be measured every year. But, if Indonesia waited until the data completed, then the national logistics cost would never be measured.

Therefore, this work aims to develop national logistics cost model of Indonesia that is adjusted with the availability of data in Indonesia, and this is first work to develop the national logistics cost model. The model is developed based on the models of United States of America, Republic of Korea, and South Africa, which is adjusted with the data that are available in Indonesia.

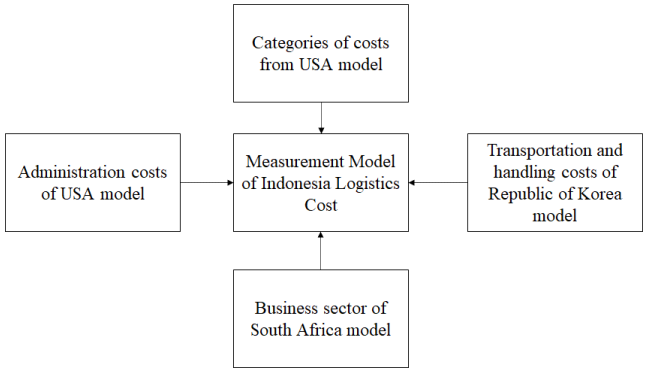


**Figure 1**. The approach to develop the measurement model of Indonesia logistics cost

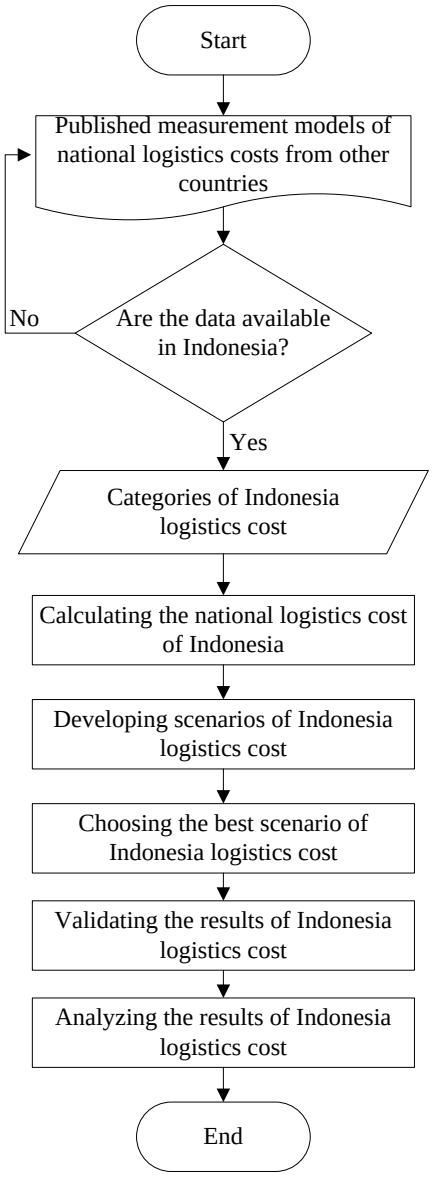


**Figure 2**. Steps to calculate Indonesia logistics cost

## 2. Material and method

Fig. 1 illustrates the approach used in this paper to develop Indonesia's logistics cost model. The primary challenge in developing Indonesia's logistics cost model is the lack of reliable data. As a result, the models used to calculate Indonesia's logistics costs were adjusted based on the availability of relevant data in the country. The United States employs three cost categories to measure its national logistics costs: transportation, inventory handling, and administrative costs. These same categories are adopted as the logistics cost categories for Indonesia [17], [18], [19], [20].

After defining the categories of national logistics costs to be used in Indonesia, the next step is to develop a model for calculating these three categories. The complete steps for calculating Indonesia's logistics costs are presented in Fig. 2. The models from the USA, the Republic of Korea, and South Africa serve as the basis for this development. The following sections describe the approach for each category of Indonesia's logistics costs.

### 2.1. *Category of transportation costs*

In the USA, transportation costs are derived from two sources: primary and secondary transportation costs. Primary transportation involves the movement of finished products from factories to warehouses, while secondary transportation refers to the delivery of finished products to customers. Transportation costs are further categorized into land, rail, water, air, pipeline transportation, and transportation support services. However, in Indonesia, data for primary and secondary transportation costs of companies is not available, as there is no single data source that provides such comprehensive information. Consequently, the USA's transportation cost measurement model cannot be applied to Indonesia.

In the Republic of Korea, transportation costs are categorized into land, rail, water, air, pipeline, and transportation support services. Land transportation costs are further divided into public and private land transportation costs. Public land transportation costs, along with rail, water, air, pipeline transportation, and transportation support services costs, are estimated based on the revenues of companies operating in these sectors. Meanwhile, private land transportation costs are calculated based on annual truck operating costs.

Indonesia adopts the Republic of Korea's approach to estimating its transportation costs for both public and private sectors. This decision is based on the availability of data in Indonesia that aligns with the Republic of Korea's model. However, pipeline transportation costs are excluded from Indonesia's transportation costs because this mode of transportation is not widely used in the country. Only a limited number of companies handling specific products utilize pipeline transportation.

The data sources used for calculating national logistics costs must provide annual data, as national logistics costs are calculated on a yearly basis. Therefore, in this study, companies listed on the Indonesia Stock Exchange (IDX) are utilized, as they are required to issue or publish their financial reports annually. In addition to IDX data, financial reports from State-Owned Enterprises (BUMN) are also used, as they

are similarly obligated to publish their reports each year.

For private transportation costs in Indonesia, the approach follows the Republic of Korea model, which uses annual truck operating costs. However, the calculation of truck operating costs is not conducted in this study, as The Asia Foundation has already calculated truck operating costs in Indonesia on a per-kilometer basis. To estimate private transportation costs in Indonesia, data on the number of trucks is required. This information is provided annually by the Directorate of Land Transportation in their official reports.

### 2.2. Category of inventory handling costs

Inventory handling costs in the USA are divided into storage, taxes, obsolescence, depreciation, inventory insurance, and warehousing costs. In Indonesia, inventories are not subject to taxes, insurance, or depreciation, as there is no regulation requiring companies to pay inventory taxes, insure their inventories, or account for inventory depreciation. Consequently, taxes, depreciation, and inventory insurance are excluded from Indonesia's inventory handling costs. Indonesia's inventory handling costs include only storage, obsolescence (commonly referred to as inventory damage risk), and warehousing costs.

For calculating storage costs, the Republic of Korea uses an approach based on the multiplication of inventory assets and interest rates. Indonesia adopts the same approach. As with transportation costs, the data sources for inventory handling costs are drawn from IDX-listed companies, which report the value of their inventory assets annually in their financial statements. Interest rate data is obtained from Bank Indonesia, which also publishes annual reports.

The Republic of Korea estimates inventory damage risk costs by multiplying inventory assets by the percentage of inventory damage. This methodology is also applied in Indonesia, as the necessary data is available. Inventory asset values are sourced from IDX-listed companies, while the percentage of damage is adjusted to align with conditions in Indonesia.

The warehousing cost estimation methods used in the USA and the Republic of Korea rely on data for public and private warehousing costs, which are not available in Indonesia. As a result, their approaches cannot be directly applied. However, warehousing costs are a critical component of national logistics costs and cannot be overlooked. Therefore, a specialized warehousing cost estimation approach has been developed specifically for Indonesia.

### 2.3. Category of administrative costs

In calculating administrative costs, Indonesia adopts the same approach as the USA, which involves multiplying a constant factor by the total transportation and inventory handling costs. For its national logistics cost calculations, South Africa categorizes its business sectors into three groups: agricultural, mining, and manufacturing. Similarly, Indonesia uses these same business sector categories as South Africa.

As a result, Indonesia's logistics cost model consists of three components: transportation, inventory handling, and administrative costs. Transportation and inventory handling costs are based on the Republic of Korea's model, administrative costs follow the USA model, and business sector classifications are derived from the South African model.

## 3. Results and discussions

### 3.1. Measurement model of Indonesia logistics cost

#### 3.1.1. National logistics cost and GDP

There are several methods to calculate Indonesia's GDP, one of which is based on business sectors [21]. Logistics costs encompass expenses arising from the flow and storage of goods, as well as information related to these activities. Accordingly, the business sectors considered in logistics cost calculations include: (a) sectors that produce goods, (b) the transportation sector responsible for the flow of goods, and (c) information technology and telecommunications sectors that support the activities of the other two sectors. Based on the GDP classification by business sector, the sectors contributing to logistics costs are: 1) agriculture, animal husbandry, forestry, and fisheries; 2) mining and excavation; 3) manufacturing industry; and 4) transportation and communication. Since this work focuses on calculating national logistics costs, it requires data that covers logistics costs at the national level. However, accessing comprehensive national logistics cost data annually is a significant challenge in Indonesia. Therefore, the use of readily accessible annual data is necessary, specifically covering the four business sectors mentioned above.

In Indonesia, a reliable source of annual data is the Indonesia Stock Exchange (IDX), where listed companies are required to publish their annual financial reports. These companies are classified into specific business sectors according to their activities. The classification of GDP and IDX business sectors for the four sectors included in the logistics cost calculation is presented in Table A1 (see Appendices).

#### 3.1.2. National logistics cost

As mentioned previously, the main problem in calculating Indonesia's logistics cost is the lack of data related to transportation and inventory. Therefore, when developing the model, the availability of data to calculate logistics costs must be verified. This paper makes several assumptions: (1) revenues for the logistics sector are equal to the sector's costs, and (2) the companies whose data are used in this research represent all companies in Indonesia within each corresponding business sector. The notations used in this paper are provided in Table 1.

**Table 1**.
The notations

| Notations | Explanation |
|---|---|
| $C_L$ | Logistics cost in % of GDP/year |
| $C_T$ | Transportation handling cost in % of GDP/year |
| $C_I$ | Inventory carrying cost in % of GDP/year |
| $C_A$ | Administrative cost in % of GDP/year |
| $C_{TR}$ | Rail transportation cost in % of GDP/year |
| $C_{TL}$ | Land transportation cost in % of GDP/year |
| $C_{TLU}$ | Public land transportation cost in % of GDP/year |
| $C_{TLR}$ | Private land transportation cost in % of GDP/year |
| $C_{TW}$ | Water transportation cost in % of GDP/year |
| $C_{TA}$ | Air transportation cost in % of GDP/year |
| $C_{TS}$ | Transportation support service cost in % of GDP/year |
| $C_{IH}$ | Inventory holding cost in % of GDP/year |
| $C_{IR}$ | Inventory risk cost in % of GDP/year |
| $C_{IW}$ | Warehousing cost in % of GDP/year |
| $C_{IWD}$ | Depreciation cost in % of GDP/year |
| $C_{IWO}$ | Operational cost in % of GDP/year |
| $I$ | Inventories assets in Rupiah |
| $W$ | Warehouses assets in Rupiah |
| $X$ | Administrative costs rate in % |
| $i$ | Borrowing interest rate in % |
| $r$ | Risk rate in % |
| $d$ | Depreciation rate in % |
| $o$ | Operational rate in % |

According to model of United States, Republic of Korea, South Africa, and the availability of data in Indonesia, national logistics cost of Indonesia is calculated as in Eq. (1). The first category of logistics cost which transportation cost is divided into five components. They are expressed as in Eq. (2). Land transportation cost is divided into two elements. They are public land transportation cost and private land transportation cost, as expressed in Eq. (3). Public land transportation cost is estimated from the revenues of companies related to business of land transportation sector. As well as rail transportation cost, water transportation cost, air transportation cost, and transportation support service cost are estimated from the revenues of companies related to business corresponding to their sectors. But for private land transportation cost, there is a different calculation. Private land transportation cost is calculated as in Eq. (4). Inventory handling cost is divided into three components, see Eq. (5). Inventory holding cost is expressed by Eq. (6). Eq. (7) calculates the inventory risk cost. Warehousing cost is divided into two costs. They are depreciation cost and operational cost. Warehousing cost is expressed in Eq. (8). Depreciation cost is expressed in Eq. (9). Eq. (10) calculates the operationla cost. Finally, Eq. (11) states that warehouses assets are estimated about 1% from fixed assets.

$$C_L = C_T + C_I + C_A \quad (1)$$

$$C_T = C_{TR} + C_{TL} + C_{TW} + C_{TA} + C_{TS} \quad (2)$$

$$C_{TL} = C_{TLU} + C_{TLR} \quad (3)$$

$C_{TLR}$ = Operational cost of one truck (IDR/km) X average driving distance in a year (km) X number of trucks in Indonesia (4)

$$C_I = C_{IH} + C_{IR} + C_{IW} \quad (5)$$

$$C_{IH} = I \times i \quad (6)$$

$$C_{IR} = I \times r \quad (7)$$

$$C_{IW} = C_{IWD} + C_{IWO} \quad (8)$$

$$C_{IWD} = W \times d \quad (9)$$

$$C_{IWO} = I \times o \quad (10)$$

$$C_A = (C_T + C_I) \times X\% \quad (11)$$

The value of $X$ is adjusted for each scenario. Scenario chosen is scenario that appropriates with situation and condition in Indonesia. Data used for each cost are given in Table A2 in Appendices [22], [23], [24]. Considering the large number of data used to calculate the national logistics cost, this research develops a database to manage the data [25]. A program based on Macro Excel is developed to help calculate the national logistics cost. The program is also used to run every parameter scenario to determine which national logistics cost that appropriates with situation and condition in Indonesia.

### 3.2. *Application of the proposed model*

#### 3.2.1. *Scenarios of the national logistics cost*

This paper develops 25 scenarios of parameters to calculate the national logistics cost of Indonesia. This is due to the lack of data in Indonesia, so all those scenarios are developed to cover every possible value of the national logistics cost. The scenarios are generated from the combination of the values in Table 2. The values of the scenarios are applied to calculate the national logistics cost of Indonesia from the year of 2004 until 2010.

#### 3.2.2. *Validation of the proposed model*

Since 25 scenarios are developed in this paper, it is necessary to choose the scenario that best matches the situation and conditions in Indonesia, as well as to validate the results. To select the best scenario, the national logistics values for Indonesia, derived from the proposed model, are compared to the values obtained from the USA, the Republic of Korea, and Japan models [26]. The models of the USA, the Republic of Korea, and Japan are represented as functions of the borrowing interest rate and the price of petrol per liter. These two variables are selected because, in general, the national logistics cost of a country is influenced by these factors.

Eq. (12), (13), and (14) are the logistic cost model of Korea, Japan, and USA, respectively.

$$Y = 1.65X_1 - 0.03X_2 + 0.08 \quad (12)$$

$$Y = 1.27X_1 + 0.01X_2 + 0.06 \quad (13)$$

$$Y = -0.16X_1 + 0.11X_2 + 0.04 \quad (14)$$

where $Y$ denotes the national logistics cost, $X_1$ denotes the borrowing interest rate, and $X_2$ denotes the price of petrol per liter. The results of Indonesia logistics cost using the USA, The Republic of Korea, and Japan models are given in Table 3.

**Table 2.**
Scenario

| No. | Risk rate | Percent of administrative cost |
|---|---|---|
| Value 1 | 15% | 4% |
| Value 2 | 16% | 5% |
| Value 3 | 17% | 6% |
| Value 4 | 18% | 7% |
| Value 5 | 19% | 8% |

**Table 3.**
The values of Indonesia logistics cost using the USA, the Republic of Korea, and Japan models

| Year | The Republic of Korea's model | Japan's model | The USA's model |
|---|---|---|---|
| 2004 | 30.44% | 24.18% | 4.77% |
| 2005 | 31.89% | 25.30% | 4.63% |
| 2006 | 30.99% | 25.60% | 7.93% |
| 2007 | 27.61% | 23.00% | 8.26% |
| 2008 | 29.05% | 24.19% | 8.38% |

**Table 4.**
The values of SSE for every scenario

| No | Scenario | SSE |
|---|---|---|
| 1 | Scenario 1 | 13.37 |
| 2 | Scenario 2 | 10.76 |
| 3 | Scenario 3 | 8.85 |
| 4 | Scenario 4 | 7.54 |
| 5 | Scenario 5 | 6.86 |
| 6 | Scenario 6 | 11.26 |
| 7 | Scenario 7 | 9.13 |
| 8 | Scenario 8 | 7.68 |
| 9 | Scenario 9 | 6.87 |
| 10 | Scenario 10 | 6.67 |
| 11 | Scenario 11 | 9.50 |
| 12 | Scenario 12 | 7.88 |
| 13 | Scenario 13 | 6.90 |
| 14 | Scenario 14 | 6.58 |
| 15 | Scenario 15 | 6.91 |
| 16 | Scenario 16 | 8.11 |
| 17 | Scenario 17 | 7.02 |
| **18** | **Scenario 18** | **6.52*** |
| 19 | Scenario 19 | 6.74 |
| 20 | Scenario 20 | 7.60 |
| 21 | Scenario 21 | 7.16 |
| 22 | Scenario 22 | 6.53 |
| 23 | Scenario 23 | 6.56 |
| 24 | Scenario 24 | 7.28 |
| 25 | Scenario 25 | 8.66 |

As it can be seen in Table 3, the values resulted from the USA's model cannot be used as the comparation since they are far too small. Also from Table 3, it can be said that the values resulted from The Republic of Korea's model are the maximum of Indonesia logistics cost and values resulted from Japan's model are the minimum of Indonesia logistics cost. The averages of values from The Republic of Korea's model and Japan's model are the values of Indonesia logistics cost. They are used as the comparation to choose the best scenario from proposed model. Therefore, the scenario selection is based on the smallest sum square error (SSE) value for each scenario.

**Table 5.**
Indonesia logistics costs (in % of GDP)

| Year | TC | IHC | AC | NLC |
|---|---|---|---|---|
| 2004 | 17.24 | 8.37 | 1.54 | 27.15 |
| 2005 | 18.77 | 7.77 | 1.59 | 28.13 |
| 2006 | 20.46 | 8.13 | 1.72 | 30.31 |
| 2007 | 15.77 | 6.88 | 1.36 | 24.02 |
| 2008 | 17.62 | 6.77 | 1.46 | 25.85 |
| 2009 | 21.31 | 7.22 | 1.71 | 30.23 |
| 2010 | 21.12 | 7.08 | 1.69 | 29.90 |
| Avg | 18.90 | 7.46 | 1.58 | 27.94 |

Note: TC (Transportation cost), IHC (Inventory Holding Cost), AC (Administrative Cost), NLC (National Logistics Cost)

**Table 6.**
The contribution of cost to national logistics cost

| Year | Transportation cost (%) | Inventory handling cost (%) |
|---|---|---|
| 2004 | 63.51 | 30.83 |
| 2005 | 66.72 | 27.62 |
| 2006 | 67.51 | 26.83 |
| 2007 | 65.68 | 28.66 |
| 2008 | 68.16 | 26.18 |
| 2009 | 70.47 | 23.87 |
| 2010 | 70.65 | 23.69 |
| Average | 67.53 | 26.81 |

**Table 7.**
The distribution of transportation costs (in %)

| Year | Rail | Land | Water | Air | Support service |
|---|---|---|---|---|---|
| 2004 | 1.30 | 62.94 | 15.74 | 5.66 | 14.35 |
| 2005 | 1.15 | 70.75 | 11.81 | 5.08 | 11.22 |
| 2006 | 0.90 | 70.84 | 13.17 | 4.88 | 10.21 |
| 2007 | 0.95 | 69.62 | 13.22 | 6.56 | 9.65 |
| 2008 | 0.73 | 71.92 | 9.30 | 9.82 | 8.23 |
| 2009 | 0.72 | 77.41 | 9.67 | 5.89 | 6.31 |
| 2010 | 0.61 | 78.17 | 9.08 | 5.97 | 6.16 |
| Avg. | 0.91 | 71.66 | 11.71 | 6.27 | 9.45 |

The sum of squared errors (SSE) for each scenario is given in Table 4. As shown in Table 4, the smallest SSE is provided by scenario 18. Therefore, scenario 18 is the best scenario, as it has the closest value to the comparison value. Scenario 18 has a risk rate of 18% and an administrative cost percentage of 6% relative to the transportation and inventory handling costs.

### 3.3. *Indonesia logistics costs*

From the best scenario which is scenario 18, Indonesia logistics costs from 2004 until 2010 are given in Table 5. The results show that the highest percentage in logistics cost of Indonesia is transportation cost (67.53%) and the second highest is inventory handling cost (26.81%). From the result it is also known that administrative cost rate for Indonesia is 6% of the sum of the inventory handling cost and transportation cost, and the risk rate for Indonesia is 18% of inventories assets. The contribution for each category of national logistics cost can be seen in Table 6.

**Table 8**.
The distribution of inventory handling costs (in %)

| Year | IHC | IRC | WC |
|---|---|---|---|
| 2004 | 35.19 | 44.92 | 20.30 |
| 2005 | 36.31 | 43.63 | 19.75 |
| 2006 | 39.18 | 47.07 | 21.29 |
| 2007 | 31.34 | 43.63 | 19.69 |
| 2008 | 30.77 | 39.99 | 18.01 |
| 2009 | 34.25 | 46.77 | 21.06 |
| 2010 | 34.50 | 52.54 | 23.70 |
| Average | 34.55 | 45.51 | 20.54 |

Note: IHC (Inventory holding costs), IRC (Inventory risk costs), WC (Warehousing cost)

### 3.3.1. *Transportation cost*

The contribution of logistics cost elements to the transportation cost can be seen in Table 7. The contribution of each of these elements can describe how the conditions of the use of modes of transportation in Indonesia. The land transportation mode still dominates the transportation of goods in Indonesia (71.66%), followed by the water transportation mode (11.71%), the air transportation mode (6.27%), and the rail transportation mode (0.91%). It can also be seen that the use of the air transportation mode is higher than the rail transportation mode. This is because all provinces in Indonesia already have airports, but not all provinces have railroads. Most of the rail transportation modes are centered on the island of Java. Air transportation mode is easier to find and use in Indonesia than rail transportation mode. Therefore, the rail transportation mode provides the least contribution.

### 3.3.2. *Inventory holding cost*

The contribution of cost elements in inventory handling costs can be seen in Table 8. It can be seen in Table 8 that the inventory risk cost gives the largest contribution to the inventory handling cost, that is 45.51%. It is followed by the inventory holding cost of 34.50% and the warehousing cost of 20.54%.

From this paper it is known that average logistics cost of Indonesia from 2004 until 2010 is about 27.94%. It means Indonesia has the highest logistics costs compared to countries in Southeast Asia that already calculated their national logistics costs, such us Singapore (8%), Malaysia (13%), Thailand (20%), and Vietnam (25%). The causes of the high national logistics cost in Indonesia, among others, are (1) the high of operational cost of one truck in Indonesia: it can reach $0.34/km while the average in Asia only $0.22/km; (2) the short of driving distance in a year in Indonesia: it is only 21.800 km/year while the average in Asia can reach 57.000 km/year; (3) the high of borrowing interest rate in Indonesia; and (4) the type of industries in Indonesia: Indonesia is a country that produces heavy and bulky products, like agriculture products, mining products, and manufactured/processed products. There is a direct relation between volume and weight of products with logistics costs. If the volume and weight of products increase, it results in a growth in logistics costs [27], [28], [29], [30].

## 4. Conclusions

This paper has successfully developed the logistics cost measurement model for Indonesia, based on the measurement models of the United States of America, the Republic of Korea, and South Africa. The model has been adjusted to fit the data available in Indonesia. The average logistics cost of Indonesia from 2004 to 2010 for the selected scenario is 27.94% of GDP. This figure is much higher than the world average logistics cost, which is 12%. The largest contribution to Indonesia's logistics cost comes from transportation, accounting for 67.53%, followed by inventory handling costs at 26.81%, and administrative costs.

In terms of transportation costs, the largest contribution is made by land transportation, at 71.66%, followed by water transportation costs at 11.71%, transportation support services at 9.45%, air transportation at 6.27%, and rail transportation at 0.91%. For inventory handling costs, the largest contribution is made by inventory risk costs at 45.51%, followed by inventory holding costs at 34.55%, and warehousing costs at 20.54%.

The national logistics costs for Singapore, Malaysia, Thailand, and Vietnam are 8%, 13%, 20%, and 25%, respectively. Compared to countries in Southeast Asia that have calculated their national logistics costs, Indonesia has the highest national logistics cost. Indonesia's high logistics cost is attributed to the high cost of operating trucks, which is around $0.34 per kilometer, as well as the high borrowing interest rate in Indonesia. Another contributing factor to the high national logistics cost is that Indonesia is a country that produces agricultural, mining, and industrial products. Therefore, it is increasingly important for the Government of Indonesia to reduce national logistics costs to support the country's economy.

To calculate Indonesia's logistics cost in the future, statistical data from all sources mentioned in this paper must be collected annually. An application system needs to be developed to collect and calculate the national logistics cost of Indonesia. This is a suggestion for future work, as the application system is a limitation of this paper.

## Declaration statement

Nova Indah Saragih: **Conceptualization, Methodology, Resources, Investigation, Writing-Original Draft, and Data Processing**. Peri Turnip: **Software**.

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**Disclosure statement**

The authors report there are no competing interests to declare.

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**Data availability statement**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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**Appendices**

**Table A1.**
GDP and IDX classification by business sector for the four business sectors

| GDP's business sectors | IDX's business sectors |
|---|---|
| 1. Agriculture, animal husbandry, forestry and fishery<br>a. Food plants<br>b. Plantation crops<br>c. Animal husbandry<br>d. Forestry<br>e. Fishery | 1. Agriculture<br>a. Plantation<br>b. Animal husbandry<br>c. Fishery<br>d. Others |
| 2. Mining and excavation<br>a. Oil and gas mining<br>b. Non-oil and gas mining<br>c. Excavation | 2. Mining<br>a. Coal mining<br>b. Oil and gas mining<br>c. Other metal and mineral mining<br>d. Rocks mining |
| 3. Processing industry<br>a. Oil and gas industry<br>1) Petroleum refinery<br>2) Liquefied natural gas (LNG)<br>b. Non-oil and gas industry<br>1) Food, beverage and tobacco industry<br>2) Textile industry, leather goods and footwear<br>3) Wood and other products industry<br>4) Paper and printing products industry<br>5) Fertilizer, chemical and rubber products industry<br>6) Cement and non-metal mining products industry<br>7) Iron and steel base metal industry<br>8) Transportation equipment, machinery and equipment industry<br>9) Other processing products industry | 3. Processing industry<br>a. Basic and chemicals industry<br>1) Cement<br>2) Ceramics, porcelain and glass<br>3) Metals and the like<br>4) Chemicals<br>5) Plastics and packaging<br>6) Animal feed<br>7) Wood and processing<br>8) Pulp and paper<br>b. Various industries<br>1) Automotive and components<br>2) Textiles and garments<br>3) Footwear<br>4) Cables<br>5) Electronics<br>6) Others<br>c. Consumer goods industry<br>1) Food and beverage<br>2) Cigarettes<br>3) Pharmacy<br>4) Cosmetics and household goods<br>5) Household appliances |
| 4. Transportation and communication<br>a. Transportation<br>1) Rail transportation<br>2) Highway transportation<br>3) Sea transportation<br>4) River, lake and crossing transportation<br>5) Air transportation<br>6) Transportation support services<br>b. Communication | 4. Infrastructure, utilization, and transportation*<br>1) Toll roads, ports, airports and the like<br>2) Telecommunication<br>3) Transportation |

*Adjusted business sector

**Table A2.**
Sources of statistical data for logistics cost in Indonesia

| No. | Data | Costs | Sources |
|---|---|---|---|
| 1 | Revenues of companies in rail transportation | Rail transportation costs | Annual report of PT. Kereta Api Indonesia |
| 2 | Revenues of companies in land tranportation sector | Public land transportation costs | Annual report of listed companies in Indonesia Stock Exchange |
| 3 | Revenues of companies in water tranportation sector | Water transportation costs | Annual report of listed companies in Indonesia Stock Exchange |
| 4 | Revenues of companies in air tranportation sector | Air transportation costs | Annual report of listed companies in Indonesia Stock Exchange |
| 5 | Revenues of companies in transportation support service sector | Transportation support service costs | Annual report of listed companies in Indonesia Stock Exchange |
| 6 | Exchange rate of rupiah | Private land transportation costs | Annual report of Bank of Indonesia |
| 7 | Operational cost of one truck | Private land transportation costs | Investigation report of The Asia Foundation |

| No. | Data | Costs | Sources |
|---|---|---|---|
| 8 | Average driving distance in a year | Private land transportation costs | Investigation report of The Asia Foundation |
| 9 | Number of trucks in Indonesia | Private land transportation costs | Annual report of Directorate General of Land Transportation |
| 10 | Inventories assets of three sectors | Inventory holding costs | Annual report of listed companies in Indonesia Stock Exchange |
| 11 | Borrowing interest rate | Inventory holding costs | Annual report of Bank of Indonesia |
| 12 | Inventories assets of three sectors | Inventory risk costs | Annual report of listed companies in Indonesia Stock Exchange |
| 13 | Fixed assets of three sectors | Depreciation costs | Annual report of listed companies in Indonesia Stock Exchange |
| 14 | Inventories assets of three sectors | Operational costs | Annual report of listed companies in Indonesia Stock Exchange |