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Preliminary model development for archipelago country logistic system

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Research paper
Transportation management

Abstract

Indonesia, the largest island country in the world, requires a reliable logistics system to meet its people's needs. The National Logistics System Development Blueprint (SISLOGNAS) supports this process, increasing trade, economic productivity, infrastructure investment, and employment opportunities. However, Indonesia's logistics performance index is currently ranked 61st out of 139 countries surveyed. To address these issues, an initial model was developed for national logistics system variables for archipelagic countries. This research uses an exploratory factor analysis approach with Jamovi software. The study found that 50 indicators in the logistics system of an archipelagic country like Indonesia are classified into six categories: services, commodities, logistics infrastructure, modes of transportation, timeliness, and technology. These indicators interconnect to develop an effective and efficient national logistics network.

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Abstrak

Indonesia sebagai negara kepulauan terbesar di dunia membutuhkan sistem logistik yang andal untuk memenuhi kebutuhan masyarakatnya. Cetak Biru Pengembangan Sistem Logistik Nasional (SISLOGNAS) mendukung proses ini dengan meningkatkan perdagangan, produktivitas ekonomi, investasi infrastruktur, dan kesempatan kerja. Namun indeks kinerja logistik Indonesia saat ini berada di peringkat 61 dari 139 negara yang disurvei. Untuk mengatasi permasalahan tersebut, dikembangkan model awal variabel sistem logistik nasional untuk negara kepulauan. Penelitian ini menggunakan pendekatan analisis faktor eksploratif dengan software Jamovi. Studi tersebut menemukan bahwa 50 indikator dalam sistem logistik di negara kepulauan seperti Indonesia diklasifikasikan ke dalam enam kategori: jasa, komoditas, infrastruktur logistik, moda transportasi, ketepatan waktu, dan teknologi. Indikator-indikator tersebut saling berhubungan untuk mengembangkan jaringan logistik nasional yang efektif dan efisien.

Kata kunci: Sistem logistik nasional, rantai pasok, kepulauan, kebijakan, transportasi

Introduction

Indonesia is the largest island country in the world which requires a reliable logistics system to meet the needs of its people. Logistics transportation is specifically stated in Presidential Regulation number 26 of 2012 concerning the National Logistics System Development Blueprint (SISLOGNAS). The Blueprint is a support system for the national scale supply chain management process (Perpres, 2012). The existence of SISLOGNAS has increased several things including the quantity of trade between regions, productivity of the economic sector, investment in the infrastructure sector, and employment opportunities. Even until this research was compiled, the Government continued to make the development of transportation infrastructure to improve connectivity and facilitate sustainable economic growth one of its focuses in realizing the vision of a Golden Indonesia 2045, namely to become a developed and sovereign country by 2045, which coincides with the 100th anniversary of Indonesia's independence (Bappenas, 2019).

From the critical strategic matters mentioned above, there are still phenomena that are problematic and important to be addressed immediately. First, the Indonesian Logistics Performance Index in 2023 will experience a decline of 15 places to be in 61st position out of 139 countries surveyed (Arvis et al., 2018). The decrease in score occurred in four of six dimensions, which sequentially consisted of tracking and tracing, logistical competence and quality, timeliness, and international shipments. Second, inequality in the logistics transportation sector, where the distribution of logistics movements or cargo transportation, both domestic and international, is dominated by sea modes. The average domestic cargo in the sea mode is 1.2 billion tons/year, followed sequentially by the rail mode 42.2 million tons/year, the air mode 1.1 million tons/year, and the land mode 489 thousand tons/year. Meanwhile, for international cargo transportation, the average cargo by sea mode is 870 million tons/year and air mode is 420 thousand tons/year (Kementerian Perhubungan RI, 2020). Apart from that, the disparity in infrastructure in eastern and western Indonesia is quite significant. Land, sea and air transportation nodes have not been utilized optimally. Third, overall logistics costs reach 24% of Gross Domestic Product (Kemenkeu, 2023), while the world average is only 13% of the country's Gross Domestic Product. Fourth, the use of technology in Indonesia's transportation system is still 40%, while Singapore has reached 70%. Fifth, it is known that there is no special institution

appointed/assigned as the Sislognas coordinator. This institution is needed to carry out the functions of coordination, policy determination, and monitoring/evaluation (USAID & Kementerian Koordinator Bidang Perekonomian RI, 2022).

In line with the government study mentioned above, Robbins et al. (2013) emphasized that the reason why the quality of management is not running well is dominated by factors of inefficiency and effectiveness which are achieved without paying attention to efficiency. lo Storto & Evangelista (2023) also reviewed conditions in the world, where various studies were conducted with a focus on infrastructure efficiency, logistics quality and the environmental impact of the national logistics system, where according to (Arvis et al., 2018) integration with manufacturing was accompanied by the support of Industry 4.0 can achieve the most effective results. Moreover, the logistics sector has a share of 10% to 11% of GDP in developed countries and this share is likely to increase in the future.

Responding to the gap between ideal conditions as theoretical principles and actual phenomena that occur, an initial model was developed for national logistics system variables for archipelago countries. The research uses an exploratory factor analysis approach using Jamovi software. It is hoped that the results of the analysis will provide empirical evidence and a clear picture of the factors and indicators that influence this national logistics system. This research is important to improve the performance of a country's logistics system. Previous research was generally conducted at an urban scale, not a country archipelago like this research. In addition, this research considers all components of the logistics system, unlike previous research which only studied certain aspects.

Theoretical framework and hypotheses

Bowersox et al. (2019), Myerson (2019), Longshore & Cheatham (2022), Achahchah (2019) explain logistics and supply chain Logistics management refers to the interconnected activities that transfer items and information between supply chain partners. Order processing, inventory management, transportation, warehousing, material handling, packaging, and facility network design are some of these functions. Logistics management focuses on the mission, business processes, and strategies required for comprehensive logistics management. The management or operator component is critical to maintaining business continuity and increasing sales. Effective delivery management can help organizations stand out and provide a better client experience. Mastering several means of transportation, such as air, road, sea, railroads, and intermodal, is critical for good logistics management. Choosing the proper managers or operators is critical for logistics success.

Bowersox (2019) highlights the challenges logistics operators face, including inventory management. Having a large inventory can lead to higher logistics costs, but it can be controlled by implementing three strategies: centralization, outsourcing, and technology use. Centralization involves a centralized logistics group, aimed at creating differentiation in service value and reducing costs (Wheelen et al., 2018). However, only 6% of entities are aware of the implications of technological progress on logistics systems, focusing on manufacturing (Paksoy et al., 2021).

Based on previous research, researchers identified 15 dimensions/factors that influence the logistics system in island countries. Those dimensions/factors include demand (Zakharchuk et al., 2022), availability of raw materials (Desai & Bohara, 2021), quality of handling (Okyere et al., 2018; Elis Dwiana Ratnamurni et al., 2022), quality of documentation and logistics information (Muslimov & Shaburova, 2021), reliability of delivery time (Ehmke & Mattfeld, 2010), timing accuracy (Pendem, 2019; Chondrodima et al., 2022; Ogura et al., 2021), costs (Hasanpour Jesri et al., 2023; Cheng et al., 2022; Zakharchuk et al., 2022; Okyere, 2018), warehousing (Sivakumar,

2019), logistics infrastructure capacity (Wang, 2021), connectivity (Bevilacqua, 2022; Pistilli, 2020), services (Anas et al., 2020; Sadowska et al., 2020; Bazaras et al., 2023), institutional (Yashin et al., 2023), competence (Dwijaya Saputra & Kusnadi, 2021; Zamkova et al., 2023), education and training (Liu & Yang, 2023), automation (Singh, 2018; Song, 2021).

Dimension/factor of demand has rate of increase in export, purchase of goods within and between provinces as the indicators. The availability of raw materials is influenced by several indicators consisting of increases in agriculture, plantations, forestry, fisheries, livestock, and mining. The quality of handling can be measured by the most popular transportation route, whether land, train, ship, plane, land combined with an airplane, land combined with a ship, land combined with a train, combined train with an airplane, a combination train with a ship, or a combination ship with an airplane. The quality of documentation and logistical information has been highlighted as markers of the level of digitalization and the availability of applications with simple timetables, tariffs, and delivery status of items. The reliability of the delivery schedule is influenced by indicators of the level of change in the delivery service provider's service system following changes in the logistics delivery situation to achieve punctuality and punctuality of goods received by the end user. Timing accuracy is influenced by indicators such as loading capacity, route selection, and accuracy of logistics mobility estimates. Warehousing is influenced by indicators of the level of goods security, stock system speed, increasing the speed of goods ordering services, the level of goods selling prices. Logistics infrastructure capacity can be measured by the capacity of infrastructure and distribution of goods. Connectivity is influenced by connectivity to border, outermost and inland areas. Services has the level of need for improving the quality of logistics services, integrated systems, and the use of technology by logistics service providers as the indicators. Institutional can be measured by the level of community need for the availability of special logistics institutions and the level of need for integration of logistics institutions with transportation institutions. Competence has level of need for competent human resources, speed of certification process in the logistics sector, utilization of competent human resources by Logistics Service Providers, and Quantity of Logistics Service Providers who have supply chain system competence as it's indicators. Education and training can be measured by the level of need for collaborative education and training from various perspectives. Automation has level of demand for automation in logistics services and level of competition as the indicators.

Industry 4.0 can help optimize logistics systems by integrating them with manufacturing, ensuring they are responsive, collaborative, efficient, sustainable, and traceable (Arvis et al., 2018; Paksoy et al., 2021). Basic infrastructure, such as an integrated system, must be provided and used from the planning or development stage (Longshore & Cheatham, 2022). The logistics sector's share of 10% to 11% of Gross Domestic Product in developed countries is likely to increase in the future (Arvis et al., 2018), leading to reduced costs by 10% to 30% (Paksoy et al., 2021). Industry 4.0 offers flexibility, connectivity, and effective resource use, changing the perception of logistics as a cost center.

Methods

Exploratory factor analysis is used to quantitatively analyses the data of this research. According to Junaidi (2021), in exploratory factor analysis (EFA), researchers explore for a lot of indicators to establish generic factors without any prior theoretical supporting, hence this study is referred to as the theory building approach. EFA analysis results can reveal the link between unspecified latent variables and observable variables. Furthermore, in EFA, the number of latent variables is

not known before to the analysis, all latent variables are assumed to influence all observed variables, and measurement errors must be uncorrelated.

Participant and procedure

The study focuses on logistics system stakeholders such as facility providers, infrastructure providers, the government, and service users. Facility providers include delivery services, while infrastructure suppliers include state-owned airports and terminal operators. The Ministries of Transport and Trade, as well as the Regional Government, are examples of governments. Logistics industry associations, communities, and educational institutions are all examples of service users. All Indonesian entities are given a digital questionnaire in which they can answer questions on 50 different indicators.

Measure

The measurement scale used is a Likert scale which allows respondents to determine the degree of their opinion on a series of research statements. The units and scales used are scale 1 for disagreeing opinion, scale 2 for disagreeing opinion, scale 3 for agreeing opinion, and scale 4 if the respondent strongly agrees with the questionnaire statement.

Data analysis procedures

First, this study begins by converting the respondent's response data, which is initially in the form of views ranging from disagreeing to strongly agreeing, into numerical data. Then, the exploratory factor analysis is performed using Jamovi software. Jamovi makes it simple to display input and output on one screen at the same time, allowing for a rapid examination. Researcher analyses the findings of Jamovi's computations to determine the proper distribution and grouping of indicators in each dimension. There were 80 respondents who came from all the islands in Indonesia. They come from various entities that have the authority to make decisions within their organizations as expected by the researcher.

Results and discussion

Descriptive statistics

The descriptive analysis findings, as shown in Table 1, show that the questionnaire's 50 indicators/statements are appropriate for use as research tools. A standard factor loading value of >= 0.50 demonstrates this. All indicator/questionnaire statements are classified into seven factors/dimensions. Certain indications, however, were shown to have multiple factor loading values. So the researcher picked the greatest number from among them. The outcomes of this approach revealed that all indications were grouped into six factors/dimensions. Table 2 shows how researchers organise indicators by categorization. Factor/dimension 1 has 20 indications, dimension 2 has 6, dimension 3 has 10, dimension 4 has 6, dimension 5 has 4 indicators, and dimension 6 has 4. Researchers analysed the characteristics of the grouping of these indicators. The 4 new factors formed are interpreted to consist of services, commodities, logistic infrastructure, transportation modes, timeliness and technology.

Exploratory factor analysis (EFA)

The initial data in this study displays 50 indicators in the Logistics System of an archipelagic country like Indonesia that are classified into six categories: services, commodities, logistics infrastructure, modes of transportation, timeliness, and technology. Everything is interconnected to develop an effective and efficient national logistics network. This result is demonstrated by the problem of unequal cargo weights, uneven infrastructure, unintegrated modes of transportation, and a lack of technological adoption, resulting in large pricing discrepancies between eastern and western Indonesia. These findings provide an initial model for studying the link between the national logistics system and other variables in order to improve state management (see Table 1).

Table 1.
Exploratory Factor Analysis Results
Table 1.
Exploratory Factor Analysis Results by using Jamovi

Factors	1	2	3	4	5	6	7
X2.1.1		0,418				0,544	
X2.1.2						0,833	
X2.1.3						0,798	
X2.2.1		0,878					
X2.2.2		0,878					
X2.2.3		0,749					
X2.2.4		0,836					
X2.2.5		0,839					
X2.2.6		0,640					
X2.3.1	0,401						
X2.3.2	0,336					0,344	
X2.3.3	0,334		0,331				
X2.3.4				0,754			
X2.3.5				0,825			
X2.3.6	0,498		0,324				
X2.3.7			0,346	0,389			
X2.3.8				0,862			
X2.3.9				0,442			
X2.3.10				0,639			
X2.4.1	0,429				0,422		
X2.4.2		0,304	0,326		0,373		
X2.5.1		0,340	0,449		0,368		
X2.5.2			0,553		0,333		
X2.6.1					0,594		
X2.6.2	0,466				0,749		
X2.6.3	0,54				0,775		
X2.7.1			0,497				
X2.8.1	0,353		0,445		0,324		
X2.8.2	0,302		0,434		0,357		

Factors	1	2	3	4	5	6	7
X2.8.3	0,481						
X2.8.4	0,334						
X2.9.1	0,615				0,372		
X2.9.2	0,564				0,352		
X2.9.3		0,400	0,724				
X2.9.4			0,751				
X2.10.1		0,419	0,652				
X2.10.2		0,397	0,631				
X2.11.1	0,677						
X2.11.2			0,454				
X2.11.3	0,669						0,365
X2.11.4	0,698						0,333
X2.12.1	0,788						
X2.12.2	0,796						
X2.13.1	0,831						
X2.13.2	0,9						
X2.13.3	0,87						
X2.14.1	0,491				0,326		
X2.14.2	0,446		0,33				
X2.15.1	0,844						
X2.15.2	0,817						

The results of the first analysis stage identify item groupings based on factor loading criteria and their components. Table 1 shows that six items do not meet the standard loading factor of 0.50 and are grouped into six components. The KMO-MSA value is 0.883, and the p-value <0.05 indicates that the initial requirements for factor analysis have been met. The study found that 50 indicators in the logistics system of an archipelagic country like Indonesia are classified into six categories: services, commodities, logistics infrastructure, modes of transportation, timeliness, and technology.

Discussion

In the initial analysis stage of the study, the researchers utilized factor analysis to identify item groupings based on factor loading criteria and their components. Factor loading refers to the correlation between observed variables (items) and latent factors. In this case, Table 1 displayed that six items did not meet the standard loading factor of 0.50, indicating a weaker relationship with the underlying factors. These six items were then grouped into six components, possibly representing distinct aspects or dimensions within the logistics system being studied.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) value of 0.883 is a statistic used to assess the suitability of data for factor analysis. A value closer to 1 suggests that the data is well-suited for factor analysis. Additionally, a p-value <0.05 indicates statistical significance, confirming that the initial requirements for conducting factor analysis were met in the study.

Furthermore, the researchers categorized the 50 indicators in the logistics system of Indonesia into six main categories: services, commodities, logistics infrastructure, modes of transportation, timeliness, and technology. This classification provides a structured framework for evaluating and enhancing different aspects of the logistics system in Indonesia, particularly in the context of being an archipelagic country. By organizing these indicators into distinct categories, the study aims to facilitate a comprehensive assessment of the logistics system, enabling targeted improvements to enhance efficiency, effectiveness, and competitiveness in supporting economic activities and trade within Indonesia's unique archipelagic setting.

Limitations

The fact that this study only sampled from one nation limits its scope. Research might be conducted for other island countries in order to enhance conclusions and improve the efficacy and efficiency of the national logistics system.

Conclusion

This research is intended to obtain empirical evidence of the factors that influence the national logistics system in an archipelago country such as Indonesia. The research collected data using digital-based questionnaires for all stakeholders involved in the national logistics system. Analysis was carried out using exploratory factor analysis with Jamovi software. From the results of the research analysis, it shows that the indicators that influence the national logistics system are divided into six broad categories, namely services, commodities, logistics infrastructure, modes of transportation, timeliness, and technology.

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Declarations

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Availability of data and materials
Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Competing interests
No potential competing interest was reported by the authors.

Appendix

Factor	Code	Indicators
Demand	$X_{1.1.1}$	rate of increase in export
	$X_{1.1.2}$	purchase of goods within provinces
	$X_{1.1.3}$	purchase of goods between provinces
The availability of raw materials	$X_{1.2.1}$	increases in agriculture
	$X_{1.2.2}$	increases in plantations
	$X_{1.2.3}$	increases in forestry
	$X_{1.2.4}$	increases in fisheries
	$X_{1.2.5}$	increases in livestock
	$X_{1.2.6}$	increases in mining
The quality of handling		the most popular transportation route:
	$X_{1.3.1}$	land
	$X_{1.3.2}$	train
	$X_{1.3.3}$	ship
	$X_{1.3.4}$	plane
	$X_{1.3.5}$	land combined with an airplane
	$X_{1.3.6}$	land combined with a ship
	$X_{1.3.7}$	land combined with a train
	$X_{1.3.8}$	train combined with an airplane
	$X_{1.3.9}$	train combined with a ship
	$X_{1.3.10}$	ship combined with an airplane.
The quality of documentation and logistical information	$X_{1.4.1}$	markers of the level of digitalization
	$X_{1.4.2}$	the availability of applications with simple timetables, tariffs, and delivery status of items
The reliability of the delivery schedule	$X_{1.5.1}$	the level of change in the delivery service provider's service system
	$X_{1.5.2}$	changes in the logistics delivery situation to achieve punctuality
	$X_{1.5.3}$	punctuality of goods received by the end user.
Timing accuracy	$X_{1.6.1}$	loading capacity
	$X_{1.6.2}$	route selection

Factor	Code	Indicators
	$X_{1.6.3}$	accuracy of logistics mobility estimates
Warehousing	$X_{1.7.1}$	the level of goods security
	$X_{1.7.2}$	stock system speed
	$X_{1.7.3}$	increasing the speed of goods ordering services
	$X_{1.7.4}$	increasing the level of goods selling prices
Logistics infrastructure capacity	$X_{1.8.1}$	the capacity of infrastructure
	$X_{1.8.2}$	the capacity of goods distribution
Connectivity	$X_{1.9.1}$	connectivity to border areas
	$X_{1.9.2}$	connectivity to outermost areas
	$X_{1.9.3}$	connectivity to inland areas
Services	$X_{1.10.1}$	the level of need for improving the quality of logistics services
	$X_{1.10.2}$	the level of need for integrated systems
	$X_{1.10.3}$	the level of technology usage by logistics service providers
Institutional	$X_{1.11.1}$	the level of community need for the availability of special logistics institutions
	$X_{1.11.2}$	the level of need for integration of logistics institutions with transportation institutions
Competence	$X_{1.12.1}$	level of need for competent human resources
	$X_{1.12.2}$	speed of certification process in the logistics sector
	$X_{1.12.3}$	utilization of competent human resources by Logistics Service Providers
	$X_{1.12.4}$	Quantity of Logistics Service Providers who have supply chain system competence
Education and training	$X_{1.13.1}$	the level of need for collaborative education from various perspectives
	$X_{1.13.2}$	the level of need for collaborative training from various perspectives
Automation	$X_{1.14.1}$	level of demand for automation in logistics services
	$X_{1.14.2}$	level of competition as the indicators.