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Determinant Factors Influencing the Decision Making of Freight Transporters to use Multimodal Transportation in South Sulawesi

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ABSTRACT

Logistics activities play important role in transporting goods from supplier to users. Unreliable and inefficient logistics will lead to additional costs which eventually make the goods less competitive. Meanwhile, it is believed that transportation activities are the main factor in logistics. Therefore, it is necessary to improve the transportation sector in order to make logistics more efficient. This effort requires involvement of all actors, including regulator, operator, and transportation service providers. These three core actors should continuously coordinate and collaborate to construct sustainable transportation by optimally utilizing all suitable modal of transportation. Therefore, there should be a shifting from single modal pattern to multimodal pattern to transport goods from production center to final consumers. This research was aimed at investigating the determinant factors which might influence transportation service providers to shift from single modal to multimodal transportation. This research had asked 150 respondents in South Sulawesi in 2022 as respondents. Respondents represented transporters in South Sulawesi. Data collected from respondents were analyzed using Structural Equation Modelling (SEM) method. Result of analysis indicates that the determinant factors include condition of port (0.364), use of digital technology (0.332), cargo (0.199), integration of transportation services (0.105), and integration of infrastructures (0.062).

Keywords: Logistic, Transportation, Determinant factors, Multimodal

1. INTRODUCTION

Globalization has affected company operations around the world. In this era, various countries in Asia and Southeast Asia in particular are increasingly competitive. Indonesia as one of the countries in the Asian region is required to further increase the competitiveness of the economy globally. Competition between countries in the field of logistics is very tight due to increased flows of trade and investment between countries which provide significant benefits to the economy **Error! Reference source not found.**. The international economy and trade are highly dependent on the development of logistics transportation [1].

A crucial component of the commercial economic system and international economic activity is logistics. the amount of logistics costs are estimated to be between 9 – 20% of gross domestic product [2]. A country's competitiveness at the global level is measured through logistics performance [3]. To assess a nation's logistics performance, the World Bank uses six criteria: infrastructure, international shipments, customs, logistics competence and quality, timeliness, and tracking and tracing. A nation's logistics performance is determined by a number of factors, including infrastructure, international shipping, customs, quality, timeliness, tracking and tracing, and logistics competence, according to the World Bank. In 2023, the results of the Logistics Performance Index (LPI) measurement of 139 countries place Singapore in first place with a score of 4.3, followed by Finland

(4.2), Denmark (4.1) and Germany (4.1). Following Singapore, Malaysia (ranked 31st) among ASEAN nations has the highest LPI 2023 ranking, followed by Thailand (ranked 37th), Philippines (ranked 47th), Vietnam (ranked 50th), Indonesia (ranked 63rd), Cambodia (116th), and Lao PDR (ranked 82nd).. Indonesia itself experienced a significant decline of 17 ratings from 46th (2018) to 63rd (2023) with a decrease in score from 3.15 to 3.0 [4].

The lowering of the LPI rating is a challenge for Indonesia, which is located between the continents of Asia and the continent of Australia and between the Atlantic and Indian Oceans. Adequate logistics infrastructure, a reliable logistics system, and professional human resources are needed to increase Indonesia's competitiveness in the global market [5]. The logistics environment involves the coordination of many parties with their respective resources to synergize to create value advantages in providing smooth services [6]. This fundamental value starts from monitoring effectively to responding to changes in consumer behavior that makes supply chain management (SCM) more efficient. [7]. This has an impact on competitive advantage, customer value, and minimal product distribution costs [8].

Along with it, sustainability is an issue in the transportation system in densely populated areas, heavy traffic, decreased air quality and access services. The movement of people and goods is facilitated in part by the transportation system. The sustainability paradigm has shifted the search for higher operating speeds with more comprehensive goals in economic, social and environmental aspects as shown in Figure 1. Indonesia requires comprehensive transportation planning to create efficient, environmentally friendly and sustainable transportation [9]. Multimodal transportation is needed to meet consumer demands for efficient and inexpensive transportation. Multimodal transportation is the integration of two or more modes of transportation which each have their own advantages [10][11]. The primary goal of multimodal transportation is to cut expenses and delivery times. The existence of a central organisation that oversees and coordinates the operations of transportation businesses is what makes this mode of transportation unique. [12]. This integration makes transportation flows more efficient, more reliable, flexible, and sustainable [13]. Multimodality provides benefits in terms of better delivery deadlines, reduced costs, and increased flexibility in logistics [14][15]. It is anticipated that increased supply chain integration will result in lower emissions and greater resource utilisation. [16].

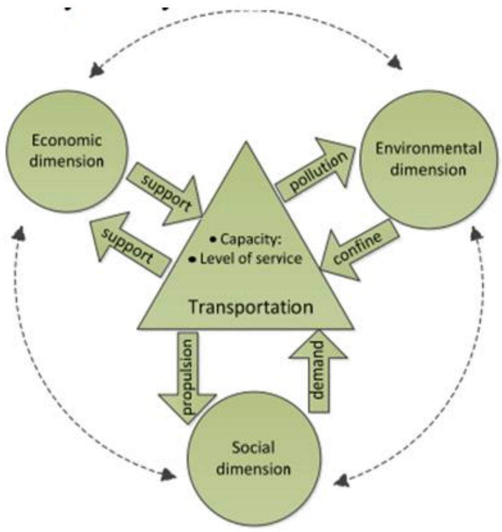

Fig.1 Sustainable transportation should consider three core aspects [42]

The Indonesian government is committed to developing multimodal transportation by building infrastructure to accelerate and expand economic growth in order to make Indonesia a developed industrial country in 2045. The Makassar-Parepare and Makassar New Port (MNP) railway lines are covered by Presidential Regulation Number 109 of 2020 concerning the Third Amendment to Presidential Regulation No. 3 of 2016 concerning the Acceleration of Implementation of National Strategic Projects, which outlines the national strategic projects. The project was motivated by the potential position of South Sulawesi Province as a major force in supporting national economic growth in Eastern Indonesia [17].The Makassar-Parepare railway is part of the Trans Sulawesi railway development program which, together with MNP, is projected to support the national logistics system. This strategic project is expected to encourage changes in the movement of freight forwarders to a multimodal pattern. The purpose of this study is to identify the critical variables that goods forwarders in South Sulawesi use to inform their decisions when utilising multimodal transportation.

2. METHODS

2.1 Research location

Due to its central location as the entry point to eastern Indonesia in the heart of the archipelago, South Sulawesi Province was the chosen site for this study in 2019. The Makassar port's role as a centre for the eastern region of Indonesia has been affirmed by the government. The province of South Sulawesi produces a range of goods of significant economic worth, so it is not surprising that it has economic growth above the national average [18]. This condition is expected to increase the growth of various regions in Eastern Indonesia.

Soekarno-Hatta Port in South Sulawesi Province which is in the middle of Makassar City is categorized as an international container port. The number of container transport flows at the Soekarno-Hatta port continues to increase every year. This condition gives an indication that domestic shipping tends to use containers so that it will experience the potential for over capacity. The development of the Soekarno-Hatta port to become an MNP was carried out with the consideration that the long distance from the origin or destination of goods to or from Makassar City was accompanied by the capacity and physical quality of the roads between the origin and destination which were still in poor condition [19]. MNP was built with integrated planning with the Makassar-Pare Pare sea and railway highway in the hope of reducing transportation costs. Reducing transportation costs is expected to have an impact on reducing the gap in prices of goods between regions and increasing the competitive advantage of products, especially those that are export-oriented.

Integrated metropolitan transportation services are needed to optimize Makassar as a strategic inter-/multimodal transportation node [20]. This is due to the fact that the bulk of international goods—roughly 90% of them—trade in Eastern Indonesia through maritime ports, such as Tonasa Biringkassi Port, Pelindo (Indonesian Port) Regional 4, and Paotere Port [18]. Makassar New Port (MNP) is a component of the national Sea Highway Programme, which aims to maximise transport services to promote both east-west transport links and the eastern Indonesian economy[21].

2.2 Characteristic of respondent

This study used 150 respondents consisting of 5 respondents representing the Indonesian National Ship Owners Association (INSA) and 145 respondents representing the Indonesian Logistics & Forwarders Association (ALFI), the Indonesian Trucking Association (APTRINDO) and the Highway Transport Association (ORGANDA). To complete the method in this study, a minimum sample size of 100 respondents is required[22]. The first criteria and indications came from field research, book reviews, and conversations with transport owners [24]. The research data was collected through in-depth interviews with various freight forwarders who are members of ALFI, INSA, APTRINDO and ORGANDA. This is done considering the success of transportation activities must meet all the demands of related parties.

2.3 Data collecting

By employing a questionnaire to gather primary data from the field, this study is quantitative. According to Zhou, the appropriateness of the data collection strategy had a direct bearing on the quality of the data that was gathered. The questionnaire consists of open and closed-ended questions which are then given to respondents for two rounds using the Delphi method. Delphi is a method for assessing unclear variables through the knowledge and competence of a group called experts. Questionnaires before being distributed to respondents must be evaluated for validity and reliability first in order to produce research data that is reliable and valid [10].

There were two rounds to the survey. Open-ended and closed questions are used in the first step, while closed questions are used in the second [25]. In the second step, the results of the previous round are given as feedback. Therefore, in the second step the opinions of colleagues greatly influence the answers of the experts. Information and expert opinions were obtained through in-depth interviews [26]. This research used 10 experts referring to various literature which recommends between 10-18 experts as a panel [27]. The questionnaire was prepared using 4 Likert scales where the weight of four indicated strongly agree (SS), three to agree (S), two to disagree (TS), and one to strongly disagree (STS). Sampling was carried out using simple random sampling method.

To assess the validity and reliability, Pearson's product moment correlation was used (Equation 1). Analysis of the total score for each variable with the total score was compared. Comparison of t-count with t-table is a significant evaluation of the correlation comparison of r-count as in equation 2. The significant correlation between the variables and the total score indicates that the investigated variables can be used to identify factors influencing freight transport in South Sulawesi to switch from single mode to multimodal with a significance level of 5%.

$$r = \frac{n(\Sigma XY) - (\Sigma X\, \Sigma Y)}{\sqrt{\left[s\Sigma X^2 - (\Sigma X)^2 - \left[n\Sigma Y^2 - (\Sigma Y)^2\right]\right]}} \quad (1)$$

where the correlation coefficient (r), number of sample (s), and score of each item (X, Y). The association is then ascertained by comparing R-count with t-count and t-table t-test. The feature is valid if t count > table (two-tailed test with a significance threshold of 0.05), and vice versa. Equation 2 is used in the calculation of the t-count value.

$$t_{count} = \frac{\sqrt[r]{(n-2)}}{\sqrt{(1-r^2)}} \quad (2)$$

where the level of sinificance (tcount), correlation coefficient (r), and number of sample (n). The reliability test was performed using Cronbach's alpha (α) method, using Equation 3 and Equation 4.

$$r_{11} = \left(\frac{k}{k-1}\right)\left(1 - \frac{\Sigma ab^2}{\sigma t^2}\right) \quad (3)$$

where the attribute reliability (r11), number of item (k), total varian (σt^2), and nomber of varian item ($\Sigma\sigma b^2$)

$$\sigma^2 = \frac{\Sigma X^2 \left(\frac{\Sigma X}{n}\right)}{n} \quad (4)$$

where number of subjects being investigated (n) and selected score (x). Constructs or variables can be relied upon if they contribute to cronbach's alpha (α) > 0.70. Conversely, constructs or variables are not reliable when they contribute Cronbach alpha (α) < 0.70.

2.4 Data analysis

To analyse the data, structural equation modelling, or SEM, was employed. SEM is a statistical technique that studies structural theory in a variety of phenomena using a confirmation methodology. This theory describes the "causal" process resulting from observations on a number of variables. There are two important aspects in SEM, namely: (a) the representation of the causal process by a number of structural equations, and (b) the description of the model as a form of conceptualization of the theory being studied [28].

SEM has been frequently employed by prior transportation researchers to evaluate their hypotheses [29], including the relationship between safety culture and accidents that are influenced by public transportation drivers' behaviour. [30]; to investigate the purportedly favorable relationship between equity in public transportation and the quality of that transportation [31] and to assess the level of satisfaction with New York City's bus rapid transit services[32]. Based on these various studies, SEM is an appropriate method for transportation planning and engineering.

There are two types of SEM: partial least squares structural equation modeling (PLS-SEM) with SmartPLS 3.0 and covariance-based applications (CB-SEM) with AMOS. [33]. The questionnaire items in this study were designed considering the theoretical background and confirmatory analysis of the data had to be carried out. Meanwhile, the relationship between variables was studied using path analysis using AMOS 22 software [34]. AMOS software is preferred because it uses a confirmation approach to test the research hypothesis in a structural model [35].

Variables that cannot be measured directly are called latent variables so that a measurable variable is needed to measure latent variables. This study consists of 8 latent variables: 1) port conditions, 2) digital technology, 3) cargo, 4) integration of transportation services, 5) integration of infrastructure network, 6) social responsibility, 7) government regulation, and 8) perceptions and the decision of the freight carrier in choosing multimodal transport is an endogenous latent variable. Latent variables are divided into exogenous latent variables and endogenous latent variables. Exogenous latent variables consist of variables 1) port conditions, 2) digital technology, 3) cargo, 4) integration of transportation services, 5) integration of infrastructure network, 6) social responsibility and 7) government regulation. Furthermore, the 7 variables are compiled based on various previous studies which are outlined in 58 indicators as contained in Table 1. The perceptions and decisions of freight forwarders in choosing multimodal transport are categorized as endogenous latent variables.

Table 1. Construct and indicators of multimodal transport shift

Construct	Indicators		Code	Reference
Condition of port	(a)	Capacity of cargo terminal	x_1	[36][37]
	(b)	Capacity of container yard	x_2	
	(c)	Capacity of consolidation terminal	x_3	
	(d)	Reliability of loading-unloading equipment	x_4	
	(e)	Interconnection of port internal road	x_5	
	(f)	Pavement condition of port internal road	x_6	
	(g)	Width of port internal road	x_7	
	(h)	Port illumination system	x_8	
	(i)	Drainage system	x_9	
	(j)	Availability of internal port evacuation route	x_{10}	
Integration of infrastructure network	(a)	Assurance of port access road capacity for freight trucks utilizing intermodal transport	x_{11}	[36][38]
	(b)	Reliability of pavement condition in the intersection between access road and port internal road	x_{12}	
	(c)	Reliability of geometric condition for truck maneuver in the intersection between access road and port internal road	x_{13}	
	(d)	Interconnection between access road and port internal road	x_{14}	
	(e)	Interconnection between access road and port hinterland road	x_{15}	
	(f)	Landscape integration between access road and port internal road	x_{16}	
	(g)	Layout design of functional interconnection of intermodal space	x_{17}	
Integration of Service	(a)	Accuracy of travel time of the acess trip	x_{18}	[38][39]
	(b)	Accuracy of travel time of the main trip	x_{19}	

Construct	Indicators	Code	Reference
	(c) Accuracy of travel time of the egress trip	x_{20}	
	(d) Accuracy of wating time of modal transfer/transit	x_{21}	
	(e) Accuracy of loading-unloading time	x_{22}	
	(f) Ease of loading and unloading process	x_{23}	
	(g) Assurance of safety and security on the access road	x_{24}	
	(h) Assurance of safety and security in the port internal road	x_{25}	
	(i) Ease of administration process of modal transfer/transit	x_{26}	
	(j) Frequency of transportation in the main trip	x_{27}	
	(k) Affordaibility of fare for modal transfer/transit process	x_{28}	
	(l) Affordability of fare in the main trip	x_{29}	
	(m) Assurance of integrated ticket service (seamless)	x_{30}	
Cargo	(a) Assurance of freight volume transported using multimodal transport	x_{31}	[36][39][40][23][23]
	(b) Assurance of certain freight load transportable using multimodal transport	x_{32}	
	(c) Assurance that dimension of the transported freight will not become the barrier for intermodal transportation	x_{33}	
	(d) Assurance of quality of freight transported using intermodal transportation	x_{34}	
	(e) Assurance of price of freight transported using intermodal transportation	x_{35}	
	(f) Assurance that goods are not damaged while transported using intermodal transportation	x_{36}	
Digital technology	(a) Availability and accuracy of tracking system for freight transported using intermodal transport	x_{37}	[23]
	(b) Availability and accuracy of information system of queue number	x_{38}	
	(c) Availability and accuracy of information system of modal transit/transfer wating time	x_{39}	
	(d) Availability and accuracy of information system of loading-unloading schedule	x_{40}	
	(e) Availability and accuracy of information system of departure time in the main trip	x_{41}	
	(f) Avaialbility and reliability of online application-based ticket integration system	x_{42}	
	(g) Availability and reliability of online application-based licensing integration system	x_{43}	

Construct	Indicators	Code	Reference
	(h) Availability and reliability of online application-based integrated administration system	x_{44}	
	(i) Availability and accuracy of information system for freight category transportable using intermodal transport	x_{45}	
Regulation	(a) Restriction of number of freight truck on the existing road paralel to intermodal transport route	x_{46}	[36][43][44]
	(b) Restriction of operational time of freight truck on the existing road paralel to intermodal transport route.	x_{47}	
	(c) Operational cost subsidy for freight operators	x_{48}	
	(d) Regulation on certain freight only transportable using intermodal transport	x_{49}	
	(e) Supervision on the implementation of minimum service standard for marine trasnprot	x_{50}	
	(f) Supervision the marine safety signs	x_{51}	
Social Responsibility	(a) Reduction on environmental pollution as the result of modal shift	x_{52}	[13][43][44]
	(b) Reduction on traffic congestion as the result of modal shift	x_{53}	
	(c) Improvement on humanistic transportation services as the result of modal shift	x_{54}	
	(d) Reduction on fuel consumption as the result of modal shift	x_{55}	
	(e) Reduction on traffic accident potential along the existing route as the result of intermodal transportation implementation	x_{56}	
	(f) Improvement on humanistic aspects (healthy, happy, prosperious, peaceful dan safe) along the existing route as the result of intermodal transportation implementation	x_{57}	

3. RESULTS AND DISCUSSIONS

3.1 Convergent validity test and confirmatory factor analysis

Researchers use reliability as a measure to determine convergent validity. Internal consistency of a number of indicators emphasizes convergent validity [45]. The average variance extracted (AVE) value and factor loadings are the criterion used to verify convergent validity. To demonstrate convergent validity, the average variance extracted should have a value more than 0.50 (AVE), and the absolute standardized factor loading value should be higher than 0.50 [46]. Loading factor value of 0.50 can be retained for the under-development model. Based on these criteria, indicators with a loading factor <0.50 were excluded from the analysis.

Confirmatory Factor Analysis (CFA) is carried out by measuring related and unrelated indicators directly through a predicted model to determine convergent validity. A model meets the requirements of convergent validity if the predicted model fits the data where all indicators converge well on the construct [47]. Constructs or variables can be relied upon if they contribute to cronbach's alpha (α) > 0.70. Conversely, constructs or variables are said to be unreliable when they contribute to Cronbach alpha (α) < 0.70. The main objective is to investigate whether the various indicators categorized by latent variables are still consistent in their respective constructs. Variables with high loading factor values indicate that these variables can provide support for uncovering the factors that influence the optimization of intermodal transportation. The results of the confirmation test show that several indicators must be excluded as contained in Table 2.

Table 2. Result of confirmatory test

Variable	Item	Loading Faktor λ	Error xε	Note
Condition of port	X2	0.266	0.716	failed
	X7	0.323	0.981	failed
	X9	0.410	0.411	failed
Integration of infrastructure network	X11	0.435	0.081	failed
	X12	0.370	0.038	failed
	X16	0.395	0.140	failed
Integration of service	X18	0.182	0.304	failed
Digital technology	X39	0.265	0.596	failed
	X40	0.293	0.547	failed
Regulation	X51	0.213	0.349	failed
	X52	0.182	0.254	failed

The indicator is said to be valid if the loading factor is ≥ 0.5 or ideally ≥ 0.7. Indicators that were considered failed were removed from the research modeling, and then retested. The results of the reconfirmation test are presented in Table 3. In addition, several indicators that were considered abnormal univariately were excluded from the research model. Given the large number of indicators for each variable, valid indicators can still measure research variables. Generally speaking, each variable's variance extract value from the confirmatory factor analysis (CFA) is higher than the 0.050 cut-off value, and the loading factor value is higher than 0.5. Therefore, based on the results of re-testing it is concluded that all indicators are valid and reliable.

Table 3 Result of reconfirmatory test

Variable	Item	Loading Faktor λ	Error xε	Σλ	Σε	Construct Reliability	AVE	Note
Condition of port (KP)	KP1	0.563	0.198	4.669	0.857	0.962	0.817	valid
	KP3	0.532	0.286					valid
	KP4	0.944	0.058					valid
	KP5	0.916	0.083					valid
	KP6	0.934	0.069					valid
	KP8	0.75	0.193					valid
	KP10	0.774	0.281					valid
				Reliable				
Integration of infrastructure network (PJP)	PJP3	0.964	0.113	6.440	0.707	0.983	0.894	valid
	PJP4	0.955	0.058					valid

Variable	Item	Loading Faktor λ	Error xε	Σλ	Σε	Construct Reliability	AVE	Note
	PJP5	0.864	0.166					valid
	PJP7	0.911	0.111					valid
				Reliable				
Integration of service (PP)	PP2	0.692	0.284	4.172	0.762			valid
	PP3	0.701	0.231					valid
	PP4	0.586	0.284					valid
	PP5	0.704	0.221					valid
	PP6	0.644	0.346					valid
	PP7	0.901	0.133					valid
	PP08	0.752	0.214					valid
	PP09	0.933	0.108					valid
	PP10	0.677	0.332					valid
	PP11	0.842	0.158					valid
	PP12	0.699	0.314					valid
	PP13	0.902	0.128					valid
								valid
				Reliable				
Cargo (MB)	MB1	0.975	0.031	5.351	0.839	0.972	0.851	valid
	MB2	0.986	0.017					valid
	MB3	0.868	0.159					valid
	MB4	0.959	0.094					valid
	MB5	0.836	0.216					valid
	MB6	0.827	0.222					valid
				Reliable				
Digital technology (DT)	DT1	0.572	0.146	4.61	0.553			valid
	DT4	0.666	0.119					valid
	DT5	0.538	0.164					valid
	DT6	0.864	0.06					valid
	DT7	0.876	0.057					valid
	DT8	0.809	0.082					valid
	DT9	0.857	0.071					valid
				Reliable				
Regulation (P)	P1	0.895	0.174	3.619	1.829	0.877	0.596	valid
	P2	0.708	0.446					valid
	P3	0.771	0.399					valid
	P4	0.850	0.207					valid
				Reliable				

Variable	Item	Loading Faktor λ	Error xε	Σλ	Σε	Construct Reliability	AVE	Note
Social Responsibility (TJS)	TJS1	0.881	0.168	5.371	0.804	0.973	0.857	valid
	TJS2	0.920	0.101					valid
	TJS3	0.945	0.068					valid
	TJS4	0.875	0.165					valid
	TJS5	0.869	0.155					valid
	TJS6	0.881	0.147					valid
				Reliable				
Optimization	TT	0.779	0.142	3.075	0.651	0.936	0.790	valid
	K	0.954	0.031					valid
	L	0.537	0.337					valid
	E	0.805	0.141					valid
				Reliable				

3.2 Discriminant validity test

The average square root value of each construct was compared to the correlation value between the constructs using a discriminant validity test. According to [48], the average variance per construct and its indicators should have a greater value than the variance per one construct or another. This is due to the fact that the correlation between construct pairs is projected to be less than the square root of AVE. The measuring model also demonstrates good discriminant validity because each construct's square root of AVE is greater than its correlation with other constructs [49].

The discriminant validity test was carried out to compare the correlation value between constructs with the average square root value of each construct as shown in Table 4. The mean value of the square root is the diagonal value in the table. The results of the discriminant validity test show that the correlation value between constructs for several variables is greater than the average square root value. This fact indicates that there is a correlation between constructs that is not discriminant or indistinguishable from one another.

Table 4 Result of discriminant validity test

	KP	PJP	PP	MB	DT	P	PSJ	Optimization	CR	AVE
KP	.904								0.962	0.817
PJP	.457	.945							0.983	0.894
PP	.758	.666	.925						0.958	0.856
MB	.196	.212	.179	0.923					0.972	0.851
DT	.237	.300	.351	.097	.932				0.975	0.868
P	.531	.430	.643	.192	.364	.772			0.877	0.596

TJS	.732	.596	.911	.134	.330	.702	.926		0.973	0.857
Optimization	.811	.670	.854	.440	.473	.675	.789	.889	0.936	0.79

3.3 Realiability test

The indicator consistency of latent variables, or internal data consistency, is measured by reliability tests [50]. Cronbach's alpha method with a significance level of 0.05 was used for reliability testing [51]. A construct or variable is considered reliable if it gives Cronbach's alpha > 0.70. The results of the construct reliability test are presented in Table 5. In general, the variables resulting from the Confirmatory Factor Analysis (CFA) that affect the intermodal transportation optimization variables are relatively reliable with Cronbach's alpha values for each factor > 0.70.

Table 5 Result of construct reliability test

Construct	Construct Reliability (CR)	Alpha Cronbach's
Condition of port	0.962	0.921
Integration of infrastructure network	0.983	0.975
Integration of service	0.958	0.923
Cargo	0.972	0.966
Digital technology	0.975	0.899
Regulation	0.877	0.810
Social responsibility	0.973	0.960
Optimization	0.936	0.844

3.4 Full model SEM analysis

Full structural equation modeling (Full Model SEM) estimation was carried out after the completion of CFA, involving only the indicators tested using CFA. Examining the correlation between the model's constructs, or latent variables, is the goal of testing the structural equation framework. The theoretical model framework is designed to have structural correlations including inter-factor correlations of exogenous variables and casualty correlations between component factors of road performance and road shoulder performance. Structural equation modeling is presented in Figure 2. One modeling technique that may handle both endogenous and exogenous variables is called structural equation modeling (SEM). Additionally, latent variables can be modeled, particularly with linear combinations. [49][52]. SEM consists of a structural model and a measurement model obtained from the covariance structure analysis method [49][53].

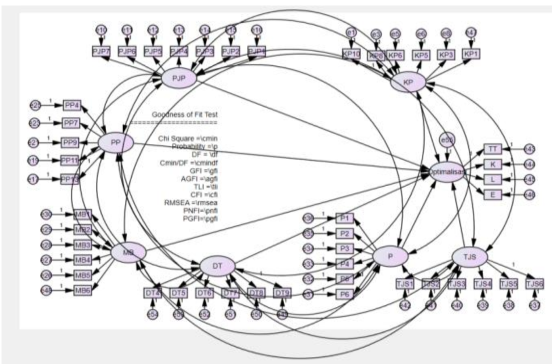

Fig.2 Full model SEM

The estimated standard coefficients or estimated weights can be seen in the standard regression weights as presented in Table 6. Each construct in the exogenous variables gives a weight of influence on the endogenous variables.

3.5 Outlier test

Outliers are observational data with unique characteristics that differ from others in the form of extreme values on single or combined variables. The Mahalanobis distance criterion was used for the multivariate outlier test. The Mahalanobis criterion is the result of evaluating the observations of each position against the observations in a set of central variables. [51].

Mahalanobis d-Squared results were then evaluated using χ^2 (chi-square) with the number of indicators used in the SEM model at the same degrees of freedom. A multivariate outlier can be identified if the Mahalanobis d-Squared value is higher than the chi-square value on df with a significance threshold of 0.001 [54].

The resulting value from the Mahalanobis test is above 81.4 (chi square table at 1% level with DF = 46). The results show that there are a number of outliers with p-values below 0.001. Based on the AMOS results, the final SEM model is presented in Figure 3.

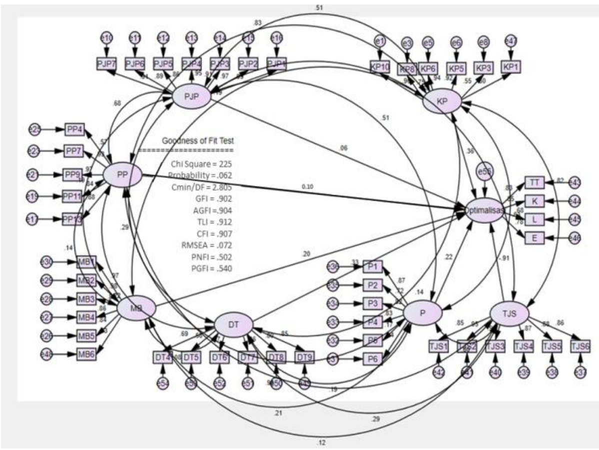

Fig.3 Result of final SEM model

The estimated standard coefficients or estimated weights can be seen in the standard regression weights as presented in Table 6. Each construct in the exogenous variables gives a weight of influence on the endogenous variables.

Table 6. Standardized regression weight of correlation among constructs

Correlation of Variable			Standard Estimate	T statistic	p-value
Optimization	<---	KP	0.364	3.472	0.000
Optimization	<---	PJP	0.062	0.714	0.002
Optimization	<---	PP	0.105	2.196	0.000
Optimization	<---	MB	0.199	3.583	0.000
Optimization	<---	DT	0.332	4.376	0.000
Optimization	<---	P	0.223	1.186	0.236
Optimization	<---	TJS	-0.908	-1.684	0.092

The results presented in Table 6 show that there is a correlation between constructs, namely the influence of port conditions, infrastructure network integration, service integration, cargo, digital technology, regulation and social responsibility on the optimization of intermodal transportation. The results showed that of the seven variables, only five variables had a significant effect, where three variables had a relatively significant effect at the 1% level (sig < 0.01) and two variables had a less significant effect because the p-value > 0.01.

In addition, the standard error values for both variables are relatively large and the critical ratio value is < ± 2.0. Therefore, if these two variables are included in the full structural equation model, optimization of intermodal transport will result in a high error rate. Based on these results, the complete structural equation model for intermodal transportation optimization can be expressed in Equation 5.

$$OPTI = 0.364KP + 0.062\ PJP + 0.105\ PP + 0.199MB + 0.332DT + \varsigma_1 \quad (5)$$

The results of the full model SEM analysis for optimizing intermodal transportation as presented in Equation 5 show that variables that have a significant effect (at the 1% level) include port conditions, service integration, cargo, and digital technology, with a p-value <0.01. The correlation between the constructs that are significant towards latent exogenous and latent endogenous constructs is that port conditions have the most dominant influence on the optimization of intermodal transportation, with a contribution of 36.4%. This means that prime port conditions must contribute to the optimization of intermodal transportation by 36.4%. The next dominant factors contributing to the optimization of intermodal transportation are digital technology, cargo, and service integration with respective contributions of 33.2%, 19.9% and 10.5%. Furthermore, the other constructs are infrastructure network integration ($p = 0.475 > 0.01$), service integration ($p = 0.050 > 0.01$), regulation ($p = 0.236 > 0.01$) and social responsibility ($p = 0.092 > 0.01$). 01) does not make a significant contribution to the optimization of intermodal transportation.

3.6 Determinant factor

3.6.1 Port condition

Multimodal transport is a coordinate system for the integration of different transport systems [55]. In a multimodal system, the port acts as an "interchange" which functions as a link between various modes of transportation to support the economy of a region [56][57][58]. The port is a point that must ensure the composition/discomposition of cargo and two or more modes of transportation so that its role in the entire transportation chain becomes very important. The port system in general can be defined as a system that is capable of directly or indirectly processing loading and unloading procedures from sea transportation means and/or vice versa, and from one sea transportation means to another sea transportation means. The large volume of cargo transported by sea throughout the world is closely related to port activity, shipping quality and efficiency [56][57]. In addition, port capacity and access are items that affect multimodal transportation [36][59]. Shipping costs, road congestion, environmental issues, and traffic safety at ports are still problems in multimodal transportation [55].

The results of this study indicate that the port has the most important impact of 36.4% in optimizing multimodal transportation. At the time this research was conducted (2019), MNP was still in the process of being developed so that it provided the largest percentage influencing the transition to multimodal transportation. At that time, goods carriers preferred to use the road because the MNP was not sufficient as a coordinator of terminal operations. This condition has the potential to make goods cannot be received more quickly, thereby disrupting the continuity of the chain of operations and customer satisfaction.

The process of developing MNP as a modern port is important in economic development because it has a major impact on reducing price disparities in Eastern Indonesia through multimodal transportation. It changes the organizational structure of the port, develops new dimensions of management and control of terminal operations, improves coordination among participants in the transport chain, and better synchronizes all processes that occur between two or more transport branches [60]. In addition, the development of the MNP is focused on ensuring a continuous flow of cargo among the various modes of transportation offered by reducing the time in which vessels are held in ports and the time in which cargo is stored in closed and open port warehouses.

3.6.2 Digital technology

The results of this study indicate that digital technology contributes 33.2% in influencing freight transporters to switch to multimodal. Shippers of goods have so far been reluctant to use multimodal transportation because it requires a lot of documents, is not monitored, and requires unlimited time. Multimodal transportation aims to ensure more efficient delivery of goods using two different modes. Therefore, the shipping time should be reduced by the transportation routes. One way is the formation of container trains and their transportation without processing along the routes. Digital technology provides information support with several benefits, including: 1) information about orders (status, delivery time, accompanying documentation); and 2) effective management of inventory, financial resources and manpower. Utilization of digital technology enables compliance with international standards regarding predictions of market needs and their fulfillment so that the attractiveness and competitiveness of transportation companies will increase.

The decision-making process for the transportation of goods can be completed from a systems process perspective. The main system modeling includes input (receiving orders), processes (from filling orders to transportation of goods), output (delivery of goods) or what is called an integrated information system. These information systems consist of data banks and consumer terminal connections with other information systems – via the internet to company information systems, ports and other transportation structures. Information on the location and arrival time of the mode of transportation provides an opportunity to prepare in advance the cargo area at the terminal. The general information system makes it possible to analyze the regularity of the formation of transport flows as well as improve the methodologies for calculating transport planning and future predictions. Multimodal transportation is a convenience solution that cannot be fulfilled by one mode of transportation.

The creation of an effective technological process for the multimodal transportation of goods between ports and terminals is necessary to speed up the movement of goods across national borders. A single customs corridor created in this way will reduce the number of container inspections to a minimum percentage. Conditions where the time for containers passing through the customs point is shortened will be an economic attraction for the development of the container business. Transportation service quality is negatively impacted by challenges with paperwork processing, passing through customs stations, erratic customs processing periods, and handling containers. Production and transportation should be integrated as the foundation for the creation and use of a single transportation process and technology. This will improve the quality of transportation and reduce the resources expended. Based on a systematic approach, developed transport process technological algorithms will create conditions for the construction of competent transport processes in multimodal freight transport, in which the interactions of all participants and elements of the transport process are coordinated [61].

It cannot be denied that information and communication technology (ICT) is a multimodal transportation nervous system related to its function which is able to provide time efficiency, data exchange, and unpredictable conditions during delivery [62]. In this system, operators play an important role in the performance of multimodal transportation services involving two or more different modes of transportation [63]. In the movement of goods within a country or internationally where there are additional procedures, operators play a role in creating a series of transportation systems that are efficient from financial, environmental and time aspects [13]. The multimodal transformation is driven by massive growth in containers that transportation is no longer possible to accommodate. Multimodal systems are the main method in international transportation today. This is because this system allows all modes to be organized in an integrated manner so as to create cost and operational efficiency. On the other hand, the advantages of each mode such as the flexibility of road transportation, trains which have a larger capacity, and the low cost of sea transportation combine to provide the best results. However, you need to be aware that the combination of different features in each mode can trigger additional obstacles such as packaging, storage and transportation conditions [64]. Another advantage, the multimodal system is that it is friendlier to the environment regarding the CO2 emissions produced compared to other goods transportation [65]. Based on these considerations, the government places greater emphasis on shifting transportation modes from unimodal to multimodal to slow down climate change.

3.6.3 Cargo

The results of this study indicate that the factors influencing transportation service providers in South Sulawesi to switch to multimodal transportation are influenced by cargo (0.199) or 19.9%. Various things that must be considered in the provision of cargo in multimodal transportation are various guarantees regarding the volume, type, dimensions, price, and quality of goods that are maintained during the delivery process. This relates to the function of the multimodal terminal in receiving and processing cargo. Multimodal terminals provide transshipment between different modes of transportation so as to create a combination of infrastructure networks and service networks for the efficiency and effectiveness of transportation financing. `Additionally, the design should be designed in such a way as to provide an adequate amount of access for trucks, wagons and barges, thereby reducing or avoiding port congestion and cargo flows with minimal loss of time and money. Other services offered to terminal users: parking, fuel intake, arranging repairs, etc. In light of the rapid increase in small size automated palletized and expensively packaged cargo, multimodal terminals at strategic points of the transport network should be further modernized and equipped with intelligent logistics systems that enable rapid access, identification and control of each piece of cargo.

The goal of multimodal transport is the efficient and rational linking of all elements of the individual transport branches into a unique and dynamic multimodal system, which significantly reduces transportation costs and at the same time improves the quality of the complete "door-to-door" service. In general, the multimodal concept should basically be simple and effective with the following development directions: 1) using standardized documents and simplifying document handling throughout the transport stream; 2) development of a modern port with improved management and control of terminal operations, increased coordination between participants in the transport chain and better synchronization; 3) containerization, especially in the multimodal phase, increasingly dominates conventional ways of connecting ports with final cargo destinations which all end in the development of hub ports where transshipment of cargo destined for end users is carried out.

Adoption of new information technologies and marketing strategies, modernization of road and rail infrastructure, renovation of already-existing multimodal terminals to accommodate the needs of different modes of transportation, and marketing tactics all contribute to the promotion of ports, heightened competition in maritime container transport, and the eventual creation of a new level of service. transportation and flow of goods in a multimodal chain. The benefits of a multimodal system include creating efficiencies in time, costs, and flexibility regarding potential uncertainties during logistics flows [14]. Cost efficiency can be achieved through consolidating cargo that has the same characteristics and destination where costs are charged jointly by the shipping company. Apart from that, the integration of land and air transportation in a multimodal system also provides cost efficiency [15][66][67].

3.6.4 Integration of services

One important metric for tracking the adoption of multimodal transportation is integration. Implementing sustainable passenger services like one-stop service, equal service levels, and a single, seamless service is one of the goals of multimodal transportation. Transportation infrastructure networks and integrated service networks must support the integration of multimodal transport operations. Integration as in the realization of both intramodal and intermodal integration in service networks and infrastructure, in terms of design, mentoring, and execution. Recognizing the important role of transportation, transportation needs to be arranged in an integrated service system in order to improve services to users of transportation services. 10.5% of respondents stated that service integration played a role in the shift of users to multimodal transportation.

Currently, service integration is still the main obstacle in the implementation of multimodal transportation. This is due to the lack of willingness to cooperate and coordinate between operators from different modes. This condition is a problem for commodities sent through the Makasar port such as corn, wheat flour, rice and seaweed where time efficiency is important. Therefore, collaboration and coordination between entities is needed for the success of the supply chain for various products so that the goods can be received by end customers from producers smoothly. The entities in question are logistics service providers such as expedition companies, transportation operators, terminal operators, shipping lines, and customs agents according to their role in the logistics supply chain [68]. Macro and cross-sectoral approaches are the key to the success of multimodal transportation, especially institutional and regulatory aspects [69]. The institutional approach in question is cross-sector multimodal transportation, such as port authorities as regulators, the formation of multiple operators to create balanced competition between various modes of transportation, investment regulations, financing, the role of government, the role of the private sector, and matters relating to coordination in transportation multimodal.

Collaborative involvement of multimodal cross-sectors consisting of service providers in logistics and supply chain operations will create improved operational performance [70]. For example, there are linkages between shippers, shipping lines, transportation operators, customs agents and terminal operators that are integrated in the supply chain. Information exchange is one of the efforts to create logistics integration which has an impact on cost efficiency and service improvement [71]. The development of organizational supply chains makes the role of logistics service providers more important in supply chain integration [23].

Supply chain integration aims for node efficiency, time, information and service. Efficiency of nodes in the supply chain between manufacturers, logistics providers and customers, as well as nodes. The node functions as a distribution center which requires container-based multimodal transportation to have standard and information technology-based facilities, technology, equipment that will connect links and nodes efficiently. Time efficiency can be realized through adjusting product delivery schedules from manufacturers to customers within a certain time. In this context, logistics providers play a role in estimating logistics routes according to their supply chain. This needs to be supported by providing transparent information where participants in the supply chain exchange information so that logistics services can run on time, information accuracy increases, and errors are minimal. The information must be tailored to the level and diversification of customers in the supply chain by the logistics provider so that customers have choices [69][73].

3.6.5 Infrastructure network integration

The integration of the transportation infrastructure network is needed to support the implementation of multimodal transportation. This research was obtained that the integration of infrastructure networks has an effect on changes in the interest of freight transport to use multimodal transportation by 6.2%. The infrastructure network in question is a network that is connected between land and sea. In this study, air networks were not taken into account because their numbers were very small considering that commodity traffic at the Makassar port is agricultural products. Transport by air is not possible because the costs are too high. Infrastructure network integration aims to facilitate the movement of goods from producers to final consumers effectively and efficiently through the integration of land and sea transportation.

The movement of goods by road is still the best choice for shippers because it is more efficient than sea and rail. Moreover, the government still provides a 50% tolerance for trucks above the standard tonnage. This choice affects the traffic load on the road network and accelerates road damage. Road conditions continued to deteriorate over time, and many heavy trucks tended to be overloaded. Multimodal transportation needs to be introduced to keep road construction in accordance with the design life, and the maintenance budget by sharing the use of rail and sea modes. The purpose of using multimodal transportation is to send goods from producers to consumers by providing convenience in the delivery and handling of goods with one transportation tariff [23].

Interconnections at transportation nodes—also known as intermodal terminals—that serve as gathering places for mode transfer enable the integration of transportation service and infrastructure networks in the implementation of effective and efficient intermodal/multimodal transportation. Integration of service networks includes, among other things, integrated schedules, integrated routes and routes to realize transportation services. While the integration of the infrastructure network is in the form of physical integration, namely the integration of modal transfer infrastructure for several modes that are located in one building node. Congestion due to inadequate land networks on main corridors is one of the frequently encountered transportation infrastructure problems. Apart from that, there is a lack of transportation networks from production centers to processing places then consumers to exports. Added to this is the limited capacity of bridges which causes bottlenecks, giving rise to access problems in various destination cities. Organizational problems that are not running well at borders and between modes also extend the list of problems that must be resolved. Congestion brought on by insufficient land connections between major corridors; a lack of transportation links connecting major production centers to markets for processing, consumption, and exports; physical limitations limiting bridge capacity; difficulties reaching major cities; and physical deprivation and inadequate organization at the frontier are examples of common transportation infrastructure issues. In addition to issues with road infrastructure, other transportation infrastructure problems include limited capacity for sea lanes, poor connectivity, few or nonexistent rail links, a rail network that cannot support the volume of trains running at full capacity or that cannot run larger or faster trains, and insufficient land access to the region's main ports, coupled with insufficient depth and a lack of yards. The rail situation is dire as there have been long delays in investing and updating the network.

The following transport infrastructure analysis of three features. First, the network structure that exists, which states that there are complex reciprocal relationships at all connected locations within countries and between countries, so to strengthen analysis of the impact of transportation investments and regulatory interventions must consider direct and indirect effects. Second, different modes of transportation infrastructure (sea, road, rail, air) regarding mode availability, mode quality and prices which can be adjusted to the sectoral composition of the economy. Third, distribution points are the determinants of transportation infrastructure, including ports, airports and border crossings. This point is the point where there is high congestion so that the performance of transportation services is hampered. The process of transporting goods can be carried out in an efficient and predictable manner, accessibility to facilities is a concern. The efficiency of loading, unloading, storing merchandise, and related bureaucratic procedures needs to be researched **Error! Reference source not found.**.

The results of this study state that port access road capacity guarantee for goods trucks using intermodal transportation Reliability of pavement conditions at the junction between the access road and the port internal road Reliability of the geometric conditions for maneuvering trucks at the intersection between the access road and the port internal road Interconnection between the access road and port internal road Interconnection between access road and port inland road Landscape integration between access road and port internal road layout design of functional interconnection of intermodal spaces.

4. CONCLUSION

The decision making for users of logistics services to switch from a single mode of transportation to a multimodal mode of transportation in South Sulawesi is influenced by several factors. These factors may vary depending on local conditions, the regulatory agency must understand the existing transportation problems and then collaborate with operators and logistics service actors to encourage the creation of effective and efficient multimodal transportation patterns according to the new transportation paradigm. The results show that the factors that influence transportation service providers in South Sulawesi to switch to multimodal transportation are influenced by port conditions (0.364), digital technology (0.332), cargo (0.199), integration of transportation services (0.105) and integration of infrastructure networks (0.062). In several developed countries, social responsibility and government regulations are the main determining factors for service users to switch modes of transportation. However, these factors have not yet become a stimulant for freight transport providers in South Sulawesi. Social responsibility will include reducing air pollution, reducing fuel consumption, and reducing traffic jams. In their view, there should be a contribution from the regulator, for example by providing state subsidies. In this case, regulations prohibiting the operation of freight transport during rush hour, regulating one-way traffic, or even prohibiting the use of heavy vehicles will not be effective. Based on these results serve as a basis for the government to formulate various strategic steps for developing multimodal transportation in Eastern Indonesia.

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