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Assessment of Economic and Capital Factors in the Transportation Industry of Developing Countries as a Key Element in Macro Transportation Planning

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Abstract

The economic importance of transportation can be understood by considering three effects on human economic life: the specialization of places in production, mass production, and the expansion of human settlement areas. Transportation and its development have enabled people to increase the productivity of natural economic resources by specializing production locations according to their comparative advantages and creating the conditions for mass production. They have also enhanced quality of life by allowing people to select suitable places to live in terms of climatic conditions and protection against various hazards. The main objective of this study is to identify the most appropriate investment tactics in the transportation industry of developing countries and the associated factors. For this purpose, 47 factors were identified and classified into four main categories. The research follows a descriptive–analytical method, employing statistical modeling and the analytic hierarchy process. Accordingly, a questionnaire for evaluating variables and conducting pairwise comparisons was developed. Given the accessible study population, 60 questionnaires were distributed to and collected from specialists in transportation, roads and transport, economics, and related fields. The criteria were evaluated after analyzing the questionnaire results through statistical modeling and regression, and through the analytic hierarchy process, using SPSS and Expert Choice. In the validity assessment and prioritization through factor analysis to reduce the number of variables, 12 important factors were selected. Statistical modeling and regression results identified five variables as influential in investment in the transportation industry of developing countries: traffic volume and characteristics/demand (road), freight transportation revenue (maritime), length of main lines (rail), infrastructure resources (air), and the quality and quantity of vessels and ships (type, age, number, use, etc.) (maritime). These variables were statistically significant, with Sig. < 0.05.

Keywords: *transportation industry, investment tactics, developing countries, macro planning*

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1. Introduction

Transportation is a fundamental component of economic organization because it connects production centers, markets, labor, resources, and consumers across geographical space. The efficiency of transportation systems determines the speed, reliability, and cost with which goods and people move, thereby influencing productivity, trade competitiveness, regional integration, and access to social and economic opportunities. These effects are especially consequential in developing countries, where transportation infrastructure frequently operates under conditions of rapid urbanization, rising demand, limited public resources, technological inequality, and significant regional disparities. Investment in transportation is therefore more than an engineering or infrastructure decision; it is a strategic economic choice that affects the allocation of national resources, the development of industries, the spatial distribution of economic activities, and the resilience of supply chains. Rail, road, air, and maritime transportation each require different combinations of physical infrastructure, financial resources, technology, skilled

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personnel, regulatory support, and operational capacity [1-3]. Consequently, macro transportation planning must evaluate not only the technical feasibility of projects but also their economic, financial, institutional, environmental, and social implications. Without an integrated assessment of these dimensions, capital may be allocated to projects that create substantial construction costs but provide limited long-term economic value, operational sustainability, or public benefit.

The importance of transportation investment has intensified as supply chains have become more interconnected and as firms and governments have faced increasing pressure to reconcile economic growth with environmental sustainability. Transportation infrastructure shapes the cost structure of supply chains and influences whether businesses can reach domestic and international markets efficiently. At the same time, the transportation sector is a major consumer of energy and a significant source of environmental externalities, making the quality and direction of investment particularly important. Recent studies indicate that financing mechanisms can influence the capacity of supply-chain actors to develop environmentally responsible technologies and pursue breakthrough green innovation. Supply-chain finance may facilitate knowledge spillovers from core firms to other members of the supply chain, creating financial and informational conditions that support green innovation and improve the environmental performance of interconnected enterprises [4]. This relationship is relevant to transportation because transport firms occupy central positions in supply chains and can either enable or constrain the diffusion of sustainable practices. Investment decisions in this sector must therefore consider the extent to which financial resources support modernization, energy efficiency, technological innovation, and the reduction of environmental harm rather than merely expanding conventional capacity.

The sustainable financing of transportation requires identifying the forces that shape investment priorities over the long term. In maritime transportation, for example, future financing is influenced by changes in international trade, environmental requirements, technological development, access to capital, risk conditions, infrastructure needs, and government policy. Identifying and evaluating these drivers can help policymakers and investors determine which financial strategies are most likely to support the durable development of maritime transport systems [2]. Environmental financing is equally important in other transportation modes. Water protection measures associated with transportation demonstrate that capital allocation can have consequences beyond the immediate operational boundaries of transport organizations. Financing pollution control, wastewater management, protective infrastructure, and other water-related measures can contribute to the quality of water bodies affected by transportation activities [5]. These findings show that transportation investment cannot be assessed solely through conventional financial returns. Its evaluation must also account for environmental costs, regulatory obligations, ecosystem protection, and the capacity of infrastructure to remain functional under increasingly strict sustainability requirements.

Nevertheless, transportation firms and infrastructure projects often face financial vulnerability. The sector is characterized by high fixed costs, long investment horizons, considerable exposure to fuel prices and demand fluctuations, and dependence on public policy and macroeconomic conditions. The COVID-19 crisis illustrated the sensitivity of transportation and logistics firms to abrupt disruptions in mobility, production, and trade. Evidence from Indonesian transportation and logistics companies showed that financial distress could be identified through changes in financial indicators during the initial phase of the pandemic, highlighting the importance of systematic financial monitoring and early-warning mechanisms [6]. Corporate financial performance in transportation is also associated with governance and sustainability. Research on transport and logistics firms suggests that sustainability performance and financial outcomes are interconnected and that board gender diversity may affect how firms translate sustainability commitments into financial performance [7]. These considerations imply that the economic evaluation of transportation investments should include governance quality, organizational resilience, financial health, and the ability of firms to manage shocks, rather than relying exclusively on projected traffic volumes or construction-based indicators.

Capital structure constitutes another major issue in transportation investment because infrastructure, transportation, and utility companies require substantial and continuous financing throughout their organizational life cycles. The optimal combination of debt, equity, retained earnings, public funding, and alternative financing mechanisms may change as organizations move from establishment and expansion to maturity or decline. Evidence concerning infrastructure, transportation, and utility companies indicates that firms adjust their capital

structures in response to their life-cycle positions, financing needs, risk profiles, and operational characteristics [8]. At the broader societal level, financial literacy also affects the capacity of individuals and future professionals to understand financing options, evaluate financial risk, and participate responsibly in economic decisions. Assessments of financial literacy among young people demonstrate the need to strengthen financial knowledge and decision-making capabilities in societies undergoing digital and economic transformation [9]. Although individual financial literacy and corporate transportation finance operate at different levels, both reflect the importance of informed resource allocation. Transportation planning in developing countries requires decision-makers who can interpret complex financial information, compare long-term investment alternatives, and understand the implications of funding arrangements for future public expenditure and organizational stability.

Financial transparency is particularly important where transportation organizations are publicly owned, highly regulated, or responsible for strategically significant infrastructure. Railway systems, for example, commonly involve complex relationships among government agencies, operators, infrastructure managers, contractors, and users. Limited transparency in these relationships can reduce accountability, weaken investment efficiency, and make it difficult to assess whether financial resources produce the intended operational outcomes. Research into railway transportation has identified opportunities to improve financial transparency through more systematic reporting, clearer financial structures, and stronger information flows among stakeholders [10]. However, financial information alone cannot fully represent transportation performance. Organizations also depend on nonfinancial measures related to service quality, safety, customer satisfaction, innovation, human capital, environmental responsibility, operational reliability, and institutional effectiveness. The identification of nonfinancial measures through thematic analysis demonstrates that performance evaluation must extend beyond accounting indicators to capture the multidimensional nature of organizational value creation [11]. Therefore, an effective model for evaluating transportation investment should combine financial and nonfinancial variables so that investment decisions reflect both economic feasibility and the wider performance of transportation systems.

Institutional arrangements for delivering transportation infrastructure also affect investment risk and capital efficiency. Public-private partnerships have become an important method of financing and implementing infrastructure projects when public budgets are insufficient to meet growing transportation needs. Such partnerships can mobilize private capital, technical knowledge, and managerial capacity, but they also create complicated contractual relationships and allocate substantial risks among public agencies, private investors, contractors, lenders, and users. Contractual risk analysis in transportation infrastructure projects implemented through public-private partnerships shows that inadequate risk allocation, regulatory uncertainty, financing problems, changes in project scope, demand fluctuations, and disputes over responsibilities may undermine project performance [12]. Consequently, the selection and prioritization of transportation investments must include a careful assessment of contractual conditions and risk-sharing mechanisms. An infrastructure project that appears attractive on the basis of projected demand may become financially unsustainable if its contractual framework transfers excessive risk to one party, lacks mechanisms for managing uncertainty, or fails to align private incentives with public objectives.

The institutional context of transportation is also changing through digitalization and platform-based business models. Digital transformation can improve traffic management, logistics coordination, customer services, information exchange, and the monitoring of infrastructure and vehicles. However, the benefits of digital transformation depend on intellectual capital, including human competencies, organizational knowledge, relational networks, innovation capacity, and the ability to integrate digital technologies into existing transportation structures. A model developed for Iran's national transportation sector emphasizes the role of intellectual capital in enabling and sustaining digital transformation [13]. Digital platforms have also transformed urban transportation through transportation network companies, generating new regulatory questions concerning labor, competition, pricing, data governance, consumer protection, and the relationship between public authorities and platform operators. A systematic examination of policy change in platform capitalism shows that the regulation of transportation network companies is shaped by political contestation, institutional arrangements, and competing interpretations of innovation and public interest [14]. These developments demonstrate that transportation investment planning must anticipate technological and regulatory change. Investment

in physical assets without complementary investments in data systems, digital capabilities, skilled personnel, and adaptable governance structures may limit the effectiveness of new infrastructure.

Human and organizational factors are similarly central to the long-term performance of transportation investments. Infrastructure cannot operate safely or efficiently without competent personnel, ethical leadership, organizational trust, and a culture that supports accountability. This issue is especially evident in maritime transportation, where employees and managers make decisions that affect safety, environmental protection, cargo handling, navigation, and compliance with national and international regulations. Research on ethical capital in organizations within the maritime transportation industry highlights the importance of education, ethical values, organizational conduct, and institutional mechanisms that reinforce responsible behavior [15]. Ethical capital complements financial and intellectual capital because it shapes how resources and knowledge are used in practice. A transportation organization may possess advanced technology and adequate funding but still experience poor performance if decision-making is affected by corruption, weak accountability, conflicts of interest, or disregard for public welfare. Investment appraisal should therefore recognize organizational ethics and human resource quality as factors that influence the actual returns and social legitimacy of transportation projects.

The interaction among financial, technological, institutional, environmental, and human factors makes transportation investment a complex multicriteria decision. This complexity is greater in developing countries because investment needs commonly exceed available financial resources, while infrastructure deficiencies occur simultaneously across multiple modes. Road systems may require improvements in safety, maintenance, traffic control, and capacity; railways may need new lines, locomotives, signaling systems, and terminal facilities; airports may require modern inspection equipment, terminal improvements, specialized personnel, and better operational services; and maritime transportation may depend on port capacity, vessels, environmental protection, logistics services, and access to international corridors. These requirements cannot be addressed effectively through fragmented project selection. Macro planning must determine which variables most strongly influence investment outcomes and how limited resources can be directed toward interventions with the greatest economic and strategic value. It must also distinguish between variables that indicate demand, variables that represent existing capacity, and variables that determine whether investments can be financed, implemented, operated, and maintained.

A systematic assessment framework can help reduce this complexity by organizing relevant variables, evaluating their relative significance, and identifying those that should receive priority in investment modeling. Such a framework should incorporate traffic and freight demand, infrastructure conditions, revenues, operating costs, safety, environmental conditions, financial resources, human capital, service quality, maintenance capacity, and the technological readiness of transportation organizations. It should also recognize the differences among transportation modes while maintaining a common analytical structure that permits comparison. The use of statistical modeling can identify variables with meaningful relationships to overall investment assessments, while factor analysis can reduce a large set of overlapping indicators to a more manageable group of influential factors. Multicriteria decision-making methods can then support the weighting and prioritization of variables on the basis of expert judgment. This integrated approach is particularly useful in contexts where historical data are incomplete, institutional responsibilities are dispersed, and investment decisions must combine quantitative evidence with specialized professional knowledge.

Despite growing research on sustainable finance, corporate performance, financial distress, capital structure, transparency, contractual risk, digital transformation, platform regulation, environmental financing, intellectual capital, and organizational ethics, these themes are often examined separately. As a result, the literature provides valuable insights into individual dimensions of transportation investment but offers a less integrated understanding of how economic and capital-related factors interact across road, rail, air, and maritime transportation in developing countries. A comprehensive evaluation is needed to connect sector-specific variables with the broader requirements of macro transportation planning. Such an evaluation can assist governments, transportation organizations, investors, and planners in recognizing high-priority variables, avoiding inefficient capital allocation, strengthening financial and institutional resilience, and directing investment toward transportation systems that are economically productive, technologically adaptable, environmentally responsible, and operationally sustainable.

Accordingly, the aim of this study is to identify, evaluate, and prioritize the economic and capital-related factors

influencing investment in the road, rail, air, and maritime transportation industries of developing countries as key elements of macro transportation planning.

2. Methodology

Basic research seeks to add something new to human knowledge. The present study is quantitative in approach and applied in purpose. A descriptive–correlational method was used to collect the data. The survey method was adopted because it allows comparisons and statistical analyses. The distinguishing features of a survey are its data collection procedure and method of analysis. Surveys are used to test theories or established explanations and to develop new theories. Such studies focus on attitudes, opinions, certain information about living conditions, and categories that identify and distinguish individuals. The purpose of a survey is to determine the range of variation in responses. In a survey, each item of information represents a variable, that is, a measure for identifying differences in responses. Surveys may be descriptive, measure changes in attitudes toward a particular subject, and/or determine the relationship between one variable and another. Because the causes or consequences of the phenomenon under study may be numerous, surveys often include a series of questions measuring many different variables in order to arrive at possible explanations of a particular relationship. A questionnaire is also used to collect the data.

The research method in the present study is exploratory–descriptive. Exploratory research seeks preliminary information and a general understanding of the subject under investigation. In this type of research, the researcher does not posit a particular hypothesis and does not seek to test hypotheses. An exploratory study involves reviewing existing sources and conducting preliminary investigations concerning the subject. It asks whether sufficient theoretical discussion exists concerning the selected topic and whether conducting the study will encounter an insoluble problem that would make implementation impossible.

Descriptive studies identify and report the existing situation. In descriptive research, the researcher does not seek to test relationships between variables; instead, the objective is simply to describe one or more variables. Descriptive research occupies a particular place among research types because explanation, prediction, and prescription are not possible without a sound description.

In this study, the importance of the variables can be assessed through regression-based factor modeling, conducted using SPSS.

The selected variables in this study also comprise four main groups, introduced briefly below:

1. Rail transportation
2. Road transportation
3. Air transportation
4. Maritime transportation

Factor analysis is a general term for several multivariate statistical methods whose primary purpose is data reduction. It examines the intercorrelations among a large number of variables and ultimately classifies and explains them in terms of a limited number of general factors. Factor analysis is an interdependence method in which all variables are considered simultaneously. In other words, in this technique, which can be divided into Q-type and R-type analysis, each variable is treated as a dependent variable.

Galton was the first to lay the early foundations of factor analysis. Subsequently, in the early twentieth century, Karl Pearson proposed a factor analysis method based on multidimensional geometric space. McDonald then used this method to identify crimes and their relationship with individuals' physical characteristics. In 1904, Spearman also introduced mathematical models for this method. These efforts established the principles and foundations of factor analysis, which is now widely used across disciplines such as psychology, economics, sociology, management, medicine, and others.

The first and most important consideration in applying factor analysis is calculating the correlation matrix. It must be determined whether the purpose is to calculate correlations among variables or among respondents. If the aim is to combine variables, correlations among the variables must be calculated; in this case, the technique is called R-type factor analysis. However, if the purpose is to combine and classify respondents into different groups, a correlation matrix among respondents is calculated and used; this is called Q-type factor analysis. Because of its difficulty, the latter method is less commonly used, and methods such as cluster analysis or hierarchical grouping are used instead.

One method of selecting appropriate variables for factor analysis is to use the correlation matrix. Because factor analysis is based on noncausal correlations among variables, the correlation matrix among the variables is calculated in this method. By displaying the strength of relationships among variables, this matrix gives rise to clusters in which

variables within each cluster correlate with one another, whereas variables in different clusters do not. Another method that enables the researcher to assess whether the data are suitable for factor analysis is the KMO test. The value of this statistic always ranges between 0 and 1. If it is below 0.5, the data are unsuitable for factor analysis. If it falls between 0.5 and 0.69, factor analysis can be undertaken with greater caution. Finally, if the statistic exceeds 0.7, the correlations in the data can be considered suitable for factor analysis.

The general linear model links a number of different statistical models: analysis of variance, analysis of covariance, multivariate analysis of variance, multivariate analysis of covariance, ordinary linear regression, Student's t-test, and the F-test. The general linear model generalizes multiple linear regression models to more than one dependent variable. If Y, B, and U are column vectors, the statistical model equation represents multiple linear regressions.

Hypothesis tests using the general linear model can be performed in two ways: as multivariate tests or as multiple independent univariate tests. In multivariate tests, the columns of Y are examined together, whereas in univariate tests they are examined independently, for example, as univariate tests with the same design matrix.

Multiple linear regression generalizes linear regression by considering more than one independent variable. It is a special case of the general linear model obtained by restricting the number of dependent variables to one. The basic linear regression model is:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} + \epsilon_i. \quad (1)$$

In Equation 1, there are n observations of one dependent variable and p independent variables. Thus, Y_i is the ith observation of the dependent variable, and X_{ij} is the ith observation of the jth independent variable, where j = 1, 2, ..., p. The β_j values represent the estimated parameters, and ε_i is the ith independent and identically distributed normal error.

3. Findings and Results

Based on the feasibility studies conducted and freight transportation information from the Northeast 2 Railway General Directorate, the freight passing through the Incheh Borun rail border to/from Kazakhstan, Turkmenistan, and other countries in 2015 to 2017 was assessed and estimated. The required capacity of Incheh Borun station in 2035 for total transit, export, and import freight was projected to exceed 6,774,755 tonnes (Figure 1).



Figure 1. Regional rail transportation corridor (Railways of the Islamic Republic of Iran, 2021

Based on the above, the calculations used to forecast the annual volume of freight that can be transported up to 2035 are presented in Table 1:

Table 1. Forecast freight volume for the 1414 planning horizon (Railways of the Islamic Republic of Iran, 2021

Year	Exports		Imports		Transit		Total	
	Wagons	Tonnage	Wagons	Tonnage	Wagons	Tonnage	Wagons	Tonnage
2017	994	64,610	523	33,995	1,098	71,370	2,615	169,975
2018	1,391	90,415	732	47,580	1,538	99,970	3,661	237,965
2019	1,948	126,620	1,025	66,625	2,153	139,945	5,126	333,190
2020	2,727	177,255	1,435	93,275	3,014	195,910	7,176	466,440
2021	3,818	248,170	2,009	130,585	4,220	274,300	10,047	653,055
2022	5,345	347,425	2,813	182,845	5,907	383,955	14,065	914,225
2023	7,483	486,395	3,938	255,970	8,271	537,615	19,692	1,279,980
2024	10,476	680,940	5,514	358,410	11,578	752,570	27,568	1,791,920
2025	14,666	953,290	7,719	501,735	16,210	1,053,650	38,595	2,508,675
2026	16,720	1,086,800	8,800	572,000	18,479	1,201,135	43,999	2,859,935
2027	19,060	1,238,900	10,032	652,080	21,067	1,369,355	50,159	3,260,335
2028	21,729	1,412,385	11,436	743,340	24,016	1,561,040	57,181	3,716,765
2029	24,771	1,610,115	13,037	847,405	27,378	1,779,570	65,186	4,237,090
2030	28,239	1,835,535	14,862	966,030	31,211	2,028,715	74,312	4,830,280
2031	30,215	1,963,975	15,903	1,033,695	33,396	2,170,740	79,514	5,168,410
2032	32,330	2,101,450	17,016	1,106,040	35,734	2,322,710	85,080	5,530,200
2033	34,594	2,248,610	18,207	1,183,455	38,235	2,485,275	91,036	5,917,340
2034	37,015	2,405,975	19,482	1,266,330	40,911	2,659,215	97,408	6,331,520
2035	39,606	2,574,390	20,845	1,354,925	43,776	2,845,440	104,227	6,774,755

Table 2. Freight breakdown for different years of rail transportation (Railways of the Islamic Republic of Iran, 2021

Year	Iron and steel products	Chemical fertilizer	Petroleum products	Clinker and cement	General goods	Dried fruits and nuts, etc.	Total forecast freight
2017	48,990	7,729	51,606	38,764	12,842	10,044	169,975
2026	873,259	136,447	918,742	691,330	229,231	10,926	2,859,955
2031	1,530,917	241,172	1,614,803	1,216,345	404,749	160,424	5,168,410
2035	1,923,523	304,011	2,026,737	1,520,053	506,684	493,747	6,774,755

Table 3. Freight transportation performance and plan achievement in 1397 (Railways of the Islamic Republic of Iran, 2021)

Category	Loaded tonnage	Unloaded tonnage	Border tonne-kilometers	Origin–destination tonne-kilometers
2018 annual plan	548,994	80,335	49,370,358	498,068,098
2018 daily plan	1,504	220	135,261	1,364,570
2018 seven-month transport plan	324,884	45,340	29,216,431	294,747,148
2018 seven-month performance	130,098	63,895	14,685,747	70,391,460
First seven months of 2018 versus the same period of 2017	0.4%	33%	30%	-26%
1397 seven-month achievement (%)	40%	141%	50%	24%
Achievement chart				
2017 performance	222,949	38,366	20,514,827	159,750,407
2016 performance	201,243	39,327	17,502,084	186,048,336
2015 performance	107,884	41,994	9,529,705	44,432,464

Table 4. Tonnage index for domestic and international transportation (Railways of the Islamic Republic of Iran, 2021)

Tonnage (tonnes)					Transport type
Change in the first seven months of 1397 versus the same period of 2017 (%)	Year				
	First seven months of 2018	1396	1395	1394	

221 %	984.48	729.56	23.923	38.730	Imports	International
81 %	437.21	655.20	20.707	2.553	Exports	
-90%	204	836.4	37.097	128	Transit	
143 %	625.70	384.77	727.81	411.41	International total	
-46%	664.53	393.140	118.918	302.69	Domestic	

Of the 54 passenger airports in Iran, nine are capable of operating international flights. However, despite the operation of international flights and the presence of foreign airlines at these airports, only three are financially viable; the remaining airports in the country, both domestic and international, operate at a loss.

According to a report by a correspondent of the Iranian Students' News Agency (ISNA), Mehrabad, Mashhad, and Imam Khomeini international airports generate revenues that exceed their costs. However, the director general of Imam Khomeini International Airport recently announced that this airport's revenues and costs had also reached the break-even point.

Officials of Iran Airports Company had also promised that Isfahan and Shiraz international airports would become financially viable by the end of the previous year, but this did not occur in practice. Thus, while the number of financially viable airports is declining, the total number of airports in the country is increasing. Following efforts by members of the Islamic Consultative Assembly and the issuance of construction permits for five new airports in smaller cities, including Abadeh and Saqqez, the number of airports is expected to increase to 59.

The country's international airports, which the managing director of Iran Airports Company states will never be transferred to the private sector, are Mehrabad, Shiraz, Isfahan, Mashhad, Bandar Abbas, Imam Khomeini, Kish, Zahedan, and Tabriz airports.

The following tables present selected information and statistics on the country's road transportation:

Table 5. Summary of national road maintenance and road transportation statistics from 2011 to 2020

Indicator	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Roads under the Ministry's jurisdiction, excluding rural roads*	km	79830	81661	85623	85893	86166	87166	88012	88873	84040	84802
Freeways	km	2053	2185	2203	2401	2401	2401	2401	2401	2503	2726
Highways	km	11652	12969	14155	14488	15462	16627	16820	18122	18122	19282
Main roads	km	22052	21334	21628	24886	23879	25538	25866	25814	25814	25193
Arterial roads	km	25266	33601	34633	34633	34633	34633	34633	34633	34633	34633
Transit roads	km	—	—	24033	24245	24443	24942	24982	25235	25277	25329
Rural roads (paved and gravel)	km	126263	129074	129534	132008	128395	128394	128138	132480	134069	135540
Total length of illuminated interurban roads nationwide	km	3494	3659	3854	4156	4474	4628	4815	4995	5228	5386
Length of illuminated freeways	km	486	516	523	538	542	557	601	624	632	707
Length of illuminated highways	km	1904	1998	2100	2267	2530	2741	2863	3012	3246	3254
Operational road tunnels nationwide	Number	284	286	297	302	317	321	340	342	379	388
Total length of existing tunnels	km	132	133	142	142	154	157	177	171	199	207
Operational road bridges nationwide	Thousand units	343	—	—	342	350	356	365	365	355	364
Active road maintenance stations nationwide	Number	625	649	665	696	696	697	697	697	1069	1059
Road maintenance machinery and equipment nationwide	Units	13848	14226	14811	13793	14527	14075	11642	11916	14367	14681
Road accident black spots treated nationwide (points, sections, intersections)	Number	1004	590	648	567	648	210	277	524	220	528
Asphalt resurfacing of main and arterial roads nationwide	km	5000	5969	5188	5011	5053	3667	2420	1881	1898	2839
Asphalt laid on roads nationwide	Thousand tonnes	10700	7627	10144	12703	14737	10107	6203	5254	5364	6778

Warning, direction, and other signs installed on arterial roads nationwide	Thousand signs	376	126	210	340	293	423	572	469	284	279
Barriers installed on arterial roads nationwide (guardrails, Jersey barriers, etc.)	km	1052	279	554	964	856	1070	1004	795	1134	715
Road markings applied to arterial roads nationwide	km	55994	39948	85021	78933	90692	77965	94498	62752	56812	60831
Online traffic counters nationwide	Number	808	952	1197	1510	1786	1993	2199	2340	2429	2469
Variable message signs (VMS) nationwide	Number	168	176	193	195	195	195	203	181	193	212
Video surveillance cameras nationwide	Number	227	437	584	669	654	660	731	780	825	858
Fixed speed enforcement cameras nationwide	Number	200	225	382	—	449	982	1046	1329	1424	1694
Weigh-in-motion (WIM) systems nationwide	Number	8	16	18	17	19	28	32	35	35	60
Active freight terminals nationwide	Number	55	61	63	67	70	73	76	78	84	81
Active border freight and passenger terminals nationwide	Number	23	23	23	23	23	23	23	23	23	23
Active public passenger terminals nationwide	Number	289	287	292	294	293	293	301	306	314	309
Active roadside service complexes and TIR truck parks nationwide	Number	404	457	482	543	603	651	705	746	789	865
Highway police stations nationwide	Number	225	230	231	236	236	236	239	239	241	241
Active mechanized heavy-vehicle inspection centers nationwide	Number	106	119	131	140	141	141	144	151	157	164
Public-service road trucks nationwide (Iranian plates)	Thousand vehicles	348	378	395	423	353	360	338	358	343	360
Average age of public-service road trucks (Iranian plates)	Year	15.7	15.9	17.4	17.3	16.1	16.4	16.8	17.5	18.3	19.3
Public-service road buses nationwide (Iranian plates)	Thousand vehicles	18	19	20	21	16	16	15	15	14	14
Average age of public-service road buses (Iranian plates)	Year	11.8	11.4	13	12.7	10.1	10.2	9.4	9.9	10.6	11.6
Public-service road minibuses nationwide (Iranian plates)	Thousand vehicles	33	35	36	39	28	28	21	22	20	24
Average age of public-service road minibuses (Iranian plates)	Year	23.9	24.3	25.6	24.6	22.9	23.2	23.5	23.5	23.8	24.6
Road hire cars nationwide (Iranian plates)	Thousand vehicles	34	35	36	38	39	39	27	27	28	29
Average age of road hire cars nationwide (Iranian plates)	Year	5.3	6.8	8.5	8.2	8.9	9.6	8.6	9.2	10	10.7
Public-service road freight drivers nationwide	Thousand people	545	590	518	464	471	471	484	494	500	524
Public-service road passenger drivers nationwide	Thousand people	187	201	157	123	121	120	119	118	113	108
Active domestic freight companies and organizations nationwide	Number	4177	4178	4176	4299	4128	4293	4308	4319	4540	4662
Active domestic passenger companies and organizations nationwide	Number	2399	2440	2211	2254	2071	2151	2216	2229	2546	2599
International freight transport companies nationwide	Number	720	745	861	862	943	707	847	867	914	958
International passenger transport companies nationwide	Number	—	—	41	41	41	35	36	40	49	47
Freight tonne-kilometers nationwide (with waybills)	Million	178679	189312	191944	200867	186411	205805	224836	223170	237097	255425
Total freight transported nationwide*	Million tonnes	580	611	621	543	403	438	480	502	528	545

Freight transported nationwide (with waybills)	Million tonnes	356	375	381	385	360	388	428	442	467	500
Loaded truck trips nationwide (with waybills)	Thousand trips	26060	26822	26878	27338	25748	27195	29909	30120	30701	32311
Average distance traveled per truck trip (with waybills)	km	501	497	492	503	499	510	507	488	493	500
Average payload per truck trip (with waybills)	Tonnes	14	14	14	14	14	14	14	15	15	15
Passenger-kilometers nationwide (with manifests)	Million	58400	57983	56426	49759	47769	46981	43884	43681	43225	22972
Passengers transported nationwide (public services)*	Million people	434	416	388	308	290	271	250	278	269	106
Passengers transported nationwide (with manifests)	Million people	236	226	211	190	179	167	154	148	144	92
Passenger-carrying trips nationwide (with manifests)	Thousand trips	19060	18414	17798	16871	16058	15159	15075	15092	14668	12459
Average distance traveled per passenger trip (with manifests)	km	190	195	198	192	200	209	214	220	220	213
Average passengers per passenger trip (with manifests)	People	12	12	12	11	11	11	10	10	10	7
Imports transported into the country by truck	Thousand tonnes	2218	1534	1380	1435	1536	1991	2115	1758	1821	1446
Truck trips carrying imported goods	Thousand trips	115	79	67	71	77	107	115	89	90	73
Exports transported out of the country by truck	Thousand tonnes	5698	6918	6614	6628	6621	6228	6839	7633	9116	8066
Truck trips carrying exported goods	Thousand trips	251	303	289	286	287	270	295	335	401	357
Freight transiting the country by truck	Thousand tonnes	9245	10753	11590	13340	10919	7816	9282	9079	6806	4829
Truck trips carrying transit freight	Thousand trips	466	523	533	561	499	390	451	433	321	337
Transit freight tonne-kilometers transported by truck	Million	13102	14495	16792	17535	13777	10020	11458	10525	8151	6061
Average distance traveled by each transit truck	km	1511	1483	1501	1539	1470	1273	1230	1202	1247	1065
Passenger vehicle trips through road border crossings (inbound and outbound)	Thousand trips	103	78	74	73	86	94	123	139	149	24
Passengers transported through road border crossings by vehicle	Thousand people	1598	930	909	799	809	725	987	1066	1276	90
Total passengers through road border crossings (vehicles, transit, pedestrians, and other)	Million people	12.1	11.2	13.5	12.8	13.5	15.1	17	19	26	2.2
Interurban road accidents nationwide	Thousand cases	117	116	112	102	101	102	121	152	160	128
Fatalities in interurban road accidents nationwide	People	12232	11811	11568	10951	10860	10427	10749	11209	11866	10051
Average daily fatalities in interurban road accidents	People	34	32	32	30	30	29	29	30	31	28
Transport sector training activity	*	266	251	3328	3477	2274	2070	1529	1294	1041	529

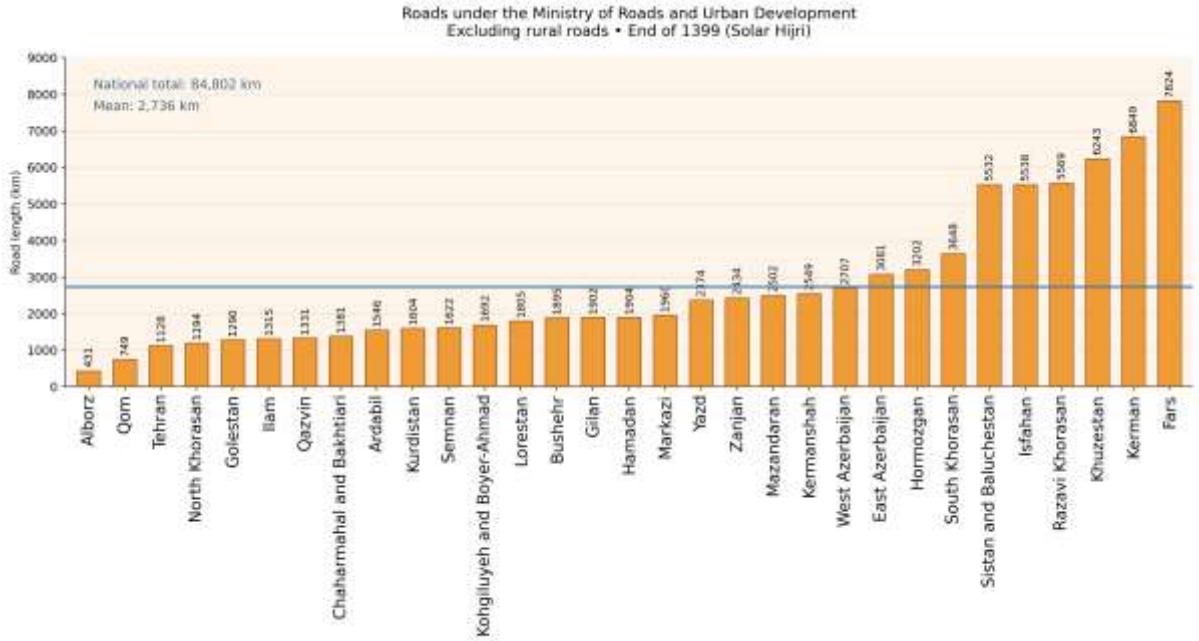


Figure 2. Length of roads under the jurisdiction of the Ministry of Roads and Urban Development, excluding rural roads, by province at the end of 1399 (Solar Hijri), in kilometers

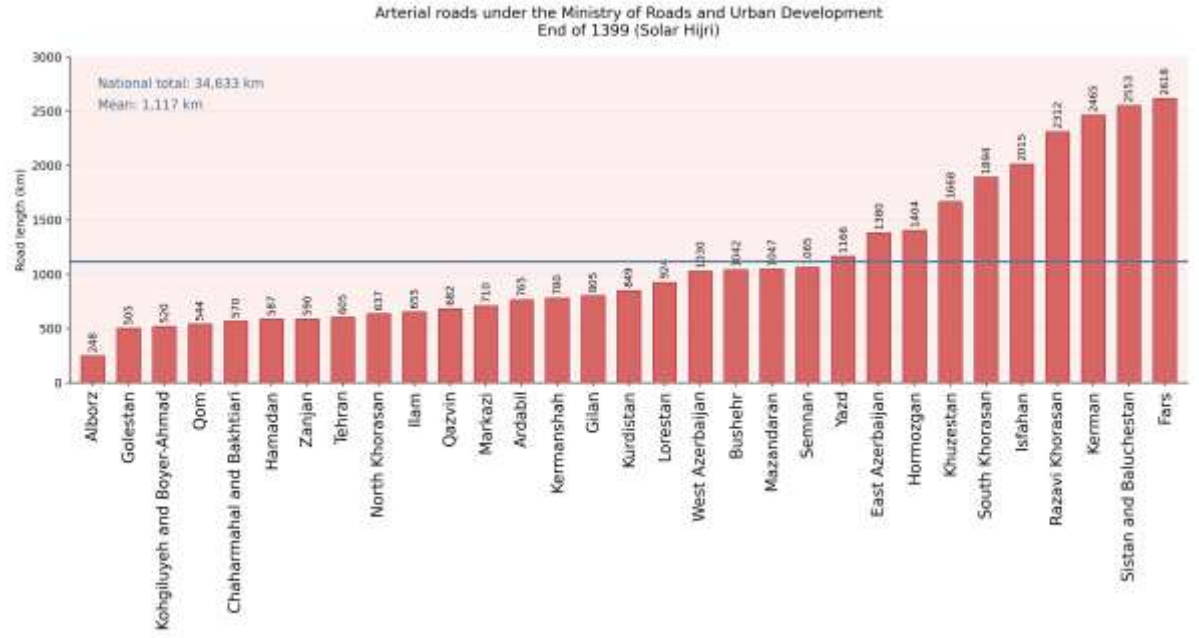


Figure 3. Length of arterial roads under the jurisdiction of the Ministry of Roads and Urban Development by province at the end of 1399 (Solar Hijri), in kilometers

In Morgan's sampling table (Table 6), N denotes the size of the target population, and S denotes the sample size to be selected from that population. For example, in an article entitled 'The Effect of Increased Motivation on the Performance of Premier League Football Players,' the target population (N) would comprise all Premier League players. Given that there are 16 teams in the Premier League, if each team has 20 players, the target population would be 320 individuals. The sample size must then be determined using Morgan's sampling table to ensure sufficient research validity. In this example, S equals 175, meaning that if a questionnaire is to be administered to a sample, the sample should comprise 175 individuals or players.

Based on the investigations conducted in Golestan Province, the available statistics, and information from some specialists and faculty members, the number of specialists in fields such as transportation and roads, economics, maritime affairs and the Ports Organization, and related areas—who have sufficient experience to comment on and evaluate the expert questionnaire concerning the value of indicators and factors influencing investment in the transportation industry of developing countries—is approximately 60 to 70. According to Morgan's table, for a population of 60 to 70 individuals, a sample of 52 to 59 is selected. Accordingly, in this study, 60 specialists were selected as the sample and as the individuals required to evaluate the AHP questionnaire.

Table 6. Morgan's sampling table, where N is the target population size and S is the sample size

S	N	S	N	S	N	S	N	S	N
10	10	80	100	162	280	260	800	338	2,800
14	15	86	110	165	290	265	850	341	3,000
19	20	92	120	169	300	269	900	346	3,500
24	25	97	130	175	320	274	950	351	4,000
28	30	103	140	181	340	278	1,000	351	4,500
32	35	108	150	186	360	285	1,100	357	5,000
36	40	113	160	181	380	291	1,200	361	6,000
40	45	118	180	196	400	297	1,300	364	7,000
44	50	123	190	201	420	302	1,400	367	8,000
48	55	127	200	205	440	306	1,500	368	9,000
52	60	132	210	210	460	310	1,600	373	10,000
56	65	136	220	214	480	313	1,700	375	15,000
59	70	140	230	217	500	317	1,800	377	20,000
63	75	144	240	225	550	320	1,900	379	30,000
66	80	148	250	234	600	322	2,000	380	40,000
70	85	152	260	242	650	327	2,200	381	50,000
73	90	155	270	248	700	331	2,400	382	75,000
76	95	159	270	256	750	335	2,600	384	100,000

Table 7. Frequency distribution of respondents' gender

Gender	Frequency	Percentage
Male	51	85
Female	9	15
Total	60	100

Table 8. Frequency distribution of specialists' educational level

Educational level	Frequency	Percentage
Bachelor's degree	15	25.0
Master's degree and doctoral students	24	40.0
Doctorate	21	35.0
Total	60	100

Table 9. Frequency distribution of specialists' age

Age	Frequency	Percentage
Under 30	6	10
31-40	24	40
41-50	21	35
Over 50	9	15
Total	60	100

Table 10. Frequency distribution of specialists' work experience

Work experience (years)	Frequency	Percentage
5-10	15	25
11-15	21	35
16-20	12	20
21-25	6	10
Over 25	6	10
Total	60	100

Table 11. Frequency distribution of specialists' fields of study

Specialization	Frequency	Percentage
Transportation and roads	21	35
Civil engineering	15	25
Architecture	3	5
Economics	12	20
Shipping and ports	9	15
Total	60	100

Next, based on the concepts discussed in the literature review and theoretical foundations of this study, the values of the indicators and factors influencing investment in the transportation industry of developing countries in the region are determined. Drawing on the understanding of the different components of the case study developed in this section, factor analysis and statistical modeling are used to prioritize important variables. The comparative MCDM method and consultation with specialists in relevant fields are used to weight the criteria and establish selection priorities, thereby presenting the values of the indicators for the case study alternatives.

Cronbach's alpha can be used to determine the reliability of a questionnaire or test, with an emphasis on internal consistency. In this method, questionnaire items are used to measure the test's reliability coefficient. Cronbach's alpha is determined by the degree of internal correlation among the variables. Values above 0.7 to 0.8 are considered good, 0.8 to 0.9 very good, and 0.9 to 1 excellent. For the variables identified to examine the correlations among the indicators and factors influencing investment in the transportation industry of developing countries, a Cronbach's alpha of 0.783 was obtained, as presented in the following table.

Reliability analysis in SPSS is performed using the menu path shown in Figure 4:

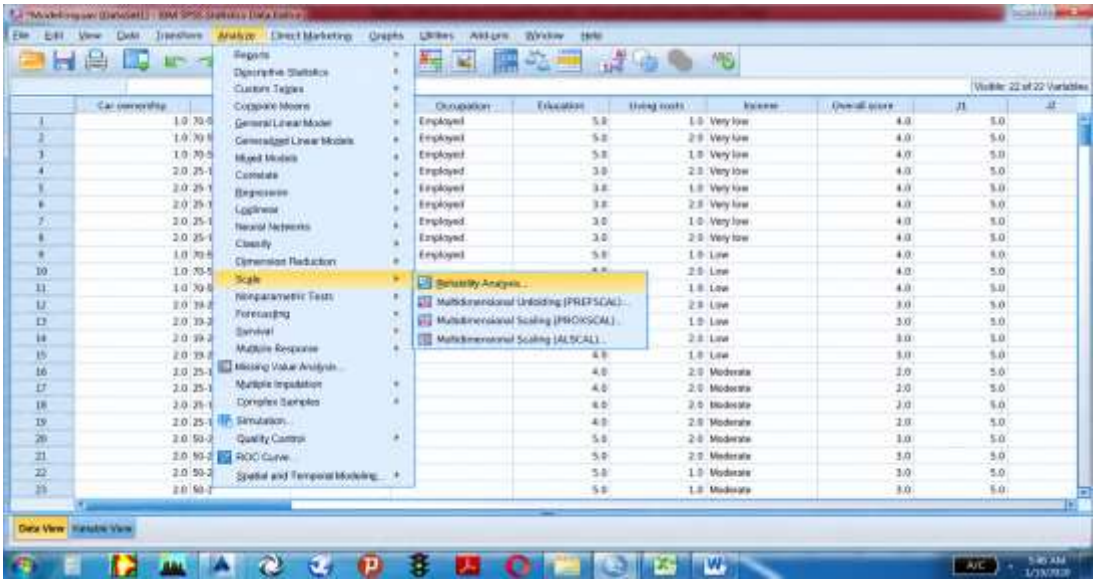


Figure 4. Using Scale and Cronbach's alpha to assess the reliability of the variables

Table 12. Cronbach's alpha for assessing the reliability of the indicators and factors influencing investment in the transportation industry of developing countries

Reliability Statistics		
Cronbach's alpha	Cronbach's alpha based on standardized items	Number of items
0.774	0.777	47

Table 13. ANOVA and Friedman test for the reliability of specialists' responses to the variables

ANOVA with Friedman Test						
		Sum of squares	df	Mean square	Friedman chi-square	Sig
Between people		410.751	60	6.846		
Within people	Between items	245.390a	46	5.335	152.465	0.000
	Residual	4270.822	2760	1.547		
	Total	4516.213	2806	1.609		
Total		4926.964	2866	1.719		

Grand mean = 3.5584

a. Kendall's coefficient of concordance, W = 0.050

The KMO test was used to examine the validity of the specialists' evaluations. The KMO index is a measure of the adequacy of the number of questionnaires in this study. In other words, the KMO index addresses whether the factors have been adequately sampled, based on pairwise correlations among the indicators and their partial correlations.

The smaller the partial correlations, the larger the KMO index, and vice versa. The closer the KMO index is to 1, the greater the sampling adequacy in selecting the indicators, or factors relevant to the problem. The threshold for sampling adequacy is a KMO value above 0.7, although values between 0.5 and 0.7 are acceptable with caution. Thus, if this index is above 0.7, the questionnaire adequacy criterion is met; otherwise, it is not. The results of the validity assessment of the specialists' evaluations are provided in Table 14.

Given the coefficient of 0.795 calculated through factor analysis in SPSS, the KMO value exceeds 0.7, indicating a satisfactory level of correlation among the factors. Factor analysis for evaluating and determining the indicators and factors influencing investment in the transportation industry of developing countries can therefore attain statistical significance.

Table 14. KMO test for assessing the validity of questionnaire evaluations

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin measure of sampling adequacy		0.849
Bartlett's test of sphericity	Approximate chi-square	2833.388
	df	1081
	Sig.	0.000

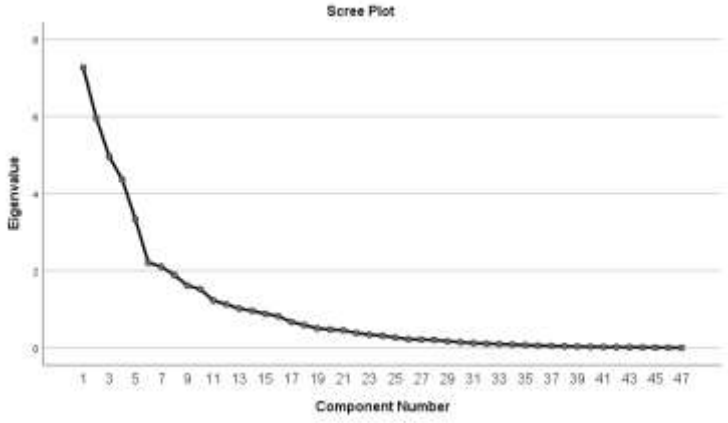


Figure 5. Scree plot for determining the number of factors

As shown by the data variance table and the y = 1 threshold on the scree plot, the first seven factors can be measured in the modeling process (Figure 5).

Table 15 shows the prioritization of the variables influencing investment in the transportation industry of developing countries in relation to the extracted factors. The rotation procedure is repeated 21 times. Each variable is assigned to the factor with which it has a high, significant correlation; the relevant values are indicated.

Table 15. Significance of variables in relation to eigenvalues and prioritization of variables influencing the investment model for the transportation industry of developing countries relative to the extracted factors

Rotated Component Matrix													
	Component												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Air traffic control center (air)	.939	-.129	-.005	.063	-.043	.038	.032	.038	.010	-.089	.015	-.058	.024
Airport services (catering, accommodation, hospitality, etc.) (air)	.880	-.048	.044	.082	-.048	.075	-.210	-.057	-.129	-.157	.021	.009	-.035
Human factors (rail)	.871	-.184	.030	.235	-.072	-.003	.123	.059	.031	-.093	-.012	-.172	-.026
Services, maintenance, and operation (maritime)	.813	.222	.065	.139	.166	.082	-.032	.128	.066	-.009	.062	.021	.037
Development project payments (rail)	.784	-.171	.054	-.129	.092	-.061	-.003	.047	.033	.370	.044	.015	.123
International trade (maritime)	.734	-.049	-.112	-.339	.047	-.145	.022	.080	.293	.140	-.021	.030	.010
Aviation accidents (air)	.697	-.069	.006	.308	.065	-.103	-.157	-.074	-.259	.119	.179	.030	.126
Control and safety equipment (road)	-.202	.844	-.181	-.109	-.062	.039	.116	-.143	.004	.215	-.071	.091	-.081
Specialized personnel (air)	-.107	.829	-.081	-.137	-.096	.163	.076	-.190	-.002	-.064	-.056	.233	-.064
Traffic lights (road)	.008	.821	.012	-.017	-.116	-.181	-.021	.118	.123	.015	.282	.057	.146
Safety and security (road)	-.115	.798	-.332	-.002	.128	.080	.186	-.018	-.059	.121	.127	.052	-.104
Vehicle safety (road)	.141	.676	.013	.245	.279	-.031	-.080	-.170	.217	.067	.009	-.071	.180
Geographical location (road)	-.075	.640	-.126	.041	.045	-.081	-.333	.091	-.134	.132	-.027	-.286	.148
International corridors (maritime)	-.003	-.078	.890	.067	-.147	.079	.205	.080	-.094	-.079	-.164	-.031	-.023
Maritime security (maritime)	-.091	-.105	.842	-.028	-.256	-.060	.099	.130	-.072	-.080	-.136	.001	.051
Container terminal pavement design and maintenance (maritime)	.026	-.072	.804	-.053	.046	.054	-.063	-.202	.195	.203	.318	.018	-.074
Loading and unloading locations (maritime)	.197	-.215	.707	-.033	.250	.159	-.104	-.100	-.061	.083	-.280	.066	-.026
Specialized personnel (maritime)	.186	-.260	.666	.030	.001	-.177	-.018	-.082	.214	-.086	.036	-.120	-.247
Loaded and unloaded tonnage (maritime)	-.155	.091	.577	.118	-.186	.264	-.198	.348	.236	-.091	-.134	-.091	.232
Maintenance and repair costs (maritime)	-.013	-.042	.575	.077	.195	.425	.016	-.046	.099	.066	.001	-.041	.327
Train control and movement equipment (rail)	.100	-.105	.071	.861	.029	-.017	.103	.085	-.069	-.177	-.047	.046	.002
Freight transportation revenue (rail)	-.011	-.062	-.075	.812	-.155	.066	.050	.308	.024	.119	.047	.047	.042
Terminal space (air)	.302	.054	.123	.781	-.036	.178	.079	-.178	.044	-.163	-.142	.048	.019
Freight transportation revenue	.183	-.033	-.105	.509	.319	.021	.178	.099	.355	-.083	.362	.175	-.368
Road network (road)	-.126	.291	-.160	.470	.241	-.008	.367	.108	-.032	.466	.049	-.253	.010
Inspection and control equipment (X-ray machines, gateways, etc.) (air)	-.008	.079	-.106	-.025	.892	-.070	-.039	.208	.112	-.079	-.005	.069	.128
Terminal quality (air)	.062	-.069	.001	-.050	.881	-.028	-.020	.190	.143	-.082	.046	.162	.024
Freight transportation revenue (maritime)	-.001	-.088	-.145	-.098	.140	.870	.161	.004	-.083	.027	-.144	.107	-.091
Number of locomotives (rail)	-.047	.167	.298	.151	-.237	.838	.084	.115	.031	.041	.051	-.052	-.048
Inspection and control equipment (maritime)	.058	-.182	.151	.226	-.351	.557	-.049	.359	.136	.070	-.243	-.172	.012
Safety (air)	-.070	-.075	-.121	-.379	-.051	-.551	.102	.111	-.302	-.137	-.276	.268	.063
Free trade and special economic zones (maritime)	.176	-.137	-.151	-.033	.342	.029	-.739	.193	-.056	.018	-.070	.063	-.117
Infrastructure resources (air)	.073	-.075	-.034	.246	.146	.077	.647	.365	.077	-.287	.124	-.058	-.140
Financial resources and credit (road)	.053	-.104	-.206	.329	.319	.074	.626	.261	.181	-.012	.075	.153	-.035
Environmental conditions (road)	.201	-.084	-.235	.031	.114	-.342	-.611	-.178	.204	.179	.072	-.026	-.221
Development project payments (road)	.056	-.106	-.107	.176	.354	.146	.105	.755	.101	-.033	.029	.000	.060

Development project payments (air)	.135	-.302	.049	.025	.262	.031	.232	.678	.215	-.059	.208	.153	-.045
Length of main lines (rail)	.383	.164	.184	.298	.270	-.075	-.051	.453	.146	.026	-.109	-.191	-.282
Condition of rail infrastructure (rail)	-.079	.094	.101	.103	.145	.104	.066	.126	.833	.103	-.118	-.005	.160
Planning, design, and construction (road)	.106	-.067	.142	-.232	.237	-.107	.000	.389	.632	-.081	.273	.074	-.101
Road safety conditions (road)	.105	.156	.011	-.106	-.148	.132	-.214	-.045	.131	.763	.049	.043	.016
Traffic volume and characteristics (road)	-.079	.551	.019	-.185	-.171	-.009	-.128	-.087	-.122	.667	-.002	-.044	.089
Quality and quantity of vessels and ships (type, age, number, use, etc.) (maritime)	-.094	-.149	.241	.108	.026	.124	-.121	-.089	.058	-.071	-.800	.133	-.132
Number of passengers / passenger-kilometers (rail)	.238	.095	-.050	.175	.393	.103	-.003	.112	.064	-.063	.531	.449	-.234
Maintenance and operation services (air)	-.193	.100	-.066	.062	.214	-.116	-.046	.028	-.014	-.007	-.049	.786	.157
Current expenditure (rail)	.067	.336	-.017	.280	.115	.194	.255	-.002	.328	.335	-.132	.443	.179
Marine environment (combating marine pollution, ships' ballast water, etc.) (maritime)	.276	.126	-.038	.030	.173	-.139	.106	-.011	.144	.076	.082	.195	.784

Extraction method: Principal component analysis.

Rotation method: Varimax with Kaiser normalization.

a. Rotation converged in 21 iterations.

Based on the prioritization of the four transportation modes and the determination of variable values, the five highest priorities for each mode are as follows:

- **Road Transportation**

Financial resources and credit (road)

Environmental conditions (road)

Planning, design, and construction (road)

Road safety conditions (road)

Traffic volume and characteristics/demand (road)

- **Rail Transportation**

Number of locomotives (rail)

Length of main lines (rail)

Condition of rail infrastructure (rail)

Number of passengers / passenger-kilometers / freight volume (rail)

Current expenditure (rail)

- **Air Transportation**

Inspection and control equipment (X-ray machines, gateways, etc.) (air)

Terminal quality (air)

Safety (air)

Infrastructure resources (air)

Maintenance and operation services (air)

- **Maritime Transportation**

Freight transportation revenue (maritime)

Inspection and control equipment (maritime)

Free trade and special economic zones (maritime)

Quality and quantity of vessels and ships (type, age, number, use, etc.) (maritime)

Marine environment (combating marine pollution, ships' ballast water, etc.) (maritime)

In determining values, the variables influencing investment in the transportation industry of developing countries receive a higher priority.

For modeling purposes, three of the five highest-priority variables in each main category that have lower correlations with one another will be selected for statistical modeling and for pairwise comparisons in the MCDM mathematical model in the next section (the underlined variables).

After examining the characteristics and variables influencing investment in the transportation industry of developing countries in the preceding section, assessing reliability and validity, and finally prioritizing the variables through factor analysis, statistical modeling through regression analysis is undertaken. Based on the model results, the dependent variable, namely the specialists' overall score concerning investment in the transportation industry of developing countries, is linked to the significance levels of the variables. A model based on 12 independent variables is presented (Table 16). The general model information includes R and its square, which measures the proportion of variability in y that can be explained by the fitted line. R^2 is the coefficient of determination, representing the percentage of total variability attributable to regression on x. The next statistic is adjusted R^2, which indicates how much of the dependent variable's total variance is explained by the independent variables; given the value of 0.719, this is acceptable. This value is, in fact, the standard deviation of the model residuals, and because it

exceeds 0.7, it is considered acceptable and appropriate. The Durbin–Watson value of 1.809, within the appropriate range of 1.5 to 2.5, indicates that the variables in this model are independent of one another.

Table 16. Assessment of the significance of the overall model

Model	R	R square	Adjusted R square	Standard error of the estimate	Durbin–Watson
1	0.848 a	0.719	0.748	0.2986	1.809

a. Predictors: (Constant)

Marine environment (combating marine pollution, ships' ballast water, etc.) (maritime); length of main lines (rail); traffic volume and characteristics/demand (road); quality and quantity of vessels and ships (type, age, number, use, etc.) (maritime); freight transportation revenue (maritime); current expenditure (rail); road safety conditions (road); safety (air); infrastructure resources (air); number of passengers/passenger-kilometers (rail); maintenance and operation services (air); and financial resources and credit (road).

b. Independent variable

Overall score

The ratio of the model data to the residual data is also approximately 77, which is considered a reliable ratio for treating the model as linear.

Table 17 presents the coefficients of the proposed statistical model after confirming the main modeling assumptions discussed in the preceding sections.

Table 17. Coefficients of the model of variables influencing investment in the transportation industry of developing countries

Coefficients[b]					
	Unstandardized coefficients		Std. coefficients		
Model	B	Standard error	Beta	t	Sig
(Constant)	1.885	0.642		5.273	0.000
Financial resources and credit (road)	-0.074	0.088	-0.144	-0.846	0.402
Traffic volume and characteristics/demand (road)	0.120	0.059	0.309	2.023	0.049
Freight transportation revenue (maritime)	0.044	0.072	0.092	2.613	0.023
Length of main lines (rail)	0.135	0.090	0.234	2.497	0.041
Number of passengers/passenger-kilometers (rail)	-0.051	0.084	-0.096	-0.602	0.550
Current expenditure (rail)	-0.048	0.070	-0.107	-0.688	0.494
Safety (air)	0.052	0.069	0.111	2.756	0.033
Infrastructure resources (air)	0.090	0.076	0.175	2.186	0.041
Maintenance and productivity services (air)	-0.034	0.080	-0.071	-0.433	0.667
Road safety conditions (road)	-0.055	0.056	-0.142	-0.982	0.331
Marine environment (combating marine pollution, ships' ballast water, etc.) (maritime)	-0.028	0.073	-0.057	-0.387	0.701

In the proposed model, five variables were identified as influential in investment in the transportation industry of developing countries: traffic volume and characteristics/demand (road), freight transportation revenue (maritime), length of main lines (rail), infrastructure resources (air), and the quality and quantity of vessels and ships (type, age, number, use, etc.) (maritime). These variables were significant, with Sig. < 0.05.

The mathematical form of the linear regression model is defined as follows:

ID = 1.885 + .12V(Road) + .044IN(Marina) + 0.135L(Rail) + 0.09S(Air) + 0.159Ship(Marina)

Figure 6 presents the regression histogram for the model, together with its standard deviation.

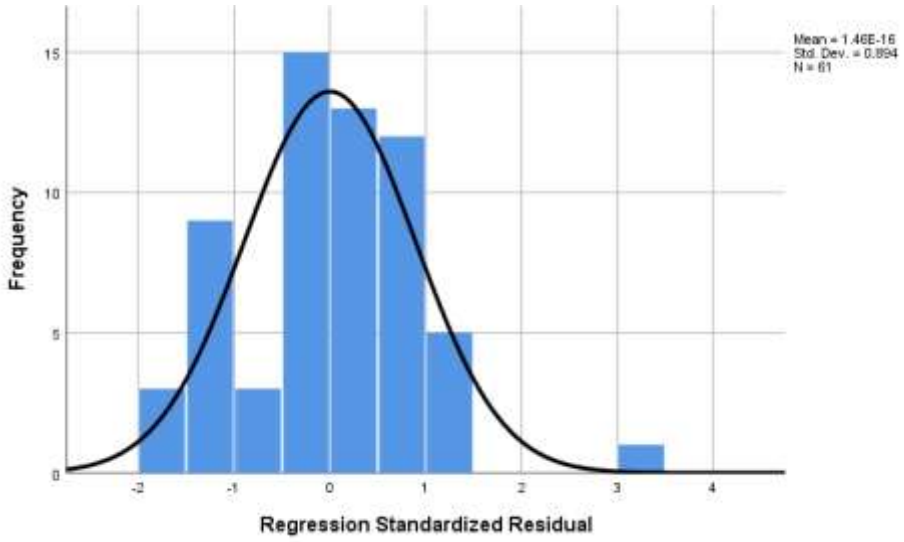


Figure 6. Histogram of the dependent variable

Another issue requiring attention is the homogeneity of residual variance. The histogram indicates that the residuals have an approximately normal distribution. The P–P curve, with the critical z* values, indicates less error in the linear regression of the model under consideration.

The Normal P–P Plot of Regression Standardized Residual for the dependent variable also indicates that the residuals are approximately normally distributed. According to this plot, if all points lie on the bisector of the first quadrant, the data follow the distribution exactly. As shown in the following figure, the data approximately follow a normal distribution (Figure 7).

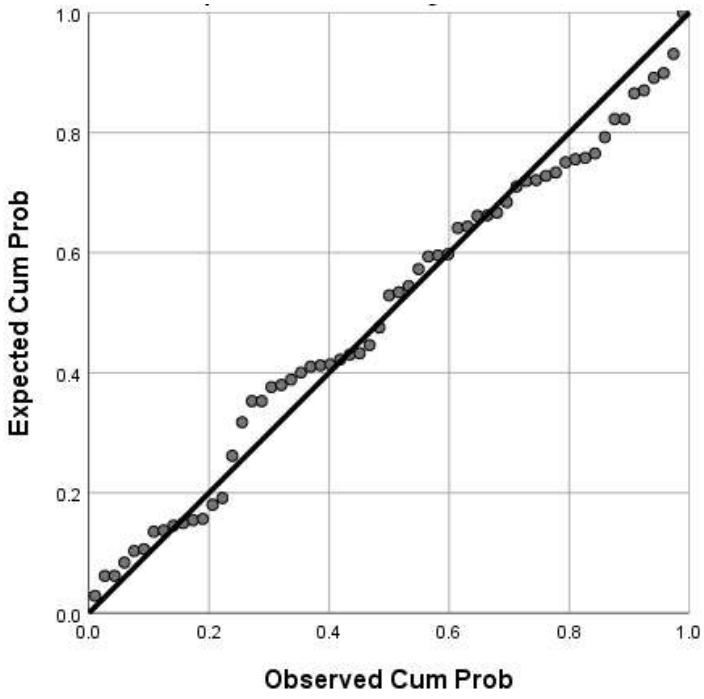


Figure 7. Distribution plot of the dependent variable and model residuals

4. Discussion and Conclusion

This study examined the economic and capital-related factors affecting investment in the road, rail, air, and maritime transportation industries of developing countries. The preliminary statistical results support the adequacy of the measurement instrument and the suitability of the data for multivariate analysis. The questionnaire demonstrated acceptable internal consistency, with a Cronbach's alpha of 0.774. The significant Friedman test ($\chi^2 = 152.465$, $p < 0.001$) further indicated that the experts meaningfully differentiated among the proposed investment factors rather than assigning similar importance to all variables. In addition, the Kaiser–Meyer–Olkin value of 0.849 and the significant Bartlett's test of sphericity ($p < 0.001$) showed that the correlation structure was suitable for factor analysis. These findings confirm that transportation investment is a multidimensional decision problem in which financial, operational, infrastructural, environmental, safety, technological, and institutional considerations are interconnected.

The regression model also displayed substantial explanatory capacity. The multiple correlation coefficient was 0.848, while the coefficient of determination indicated that the selected predictors explained approximately 71.9% of the variation in experts' overall assessment of transportation investment. The Durbin–Watson statistic of 1.809 suggested no serious autocorrelation problem. Collectively, these findings imply that a relatively limited group of carefully selected indicators can explain a considerable proportion of investment priorities across different transportation modes. This is important for developing countries, where decision makers commonly face restricted public budgets, uncertain private-sector participation, inadequate infrastructure, and competing development needs. The results therefore support the use of systematic factor prioritization instead of distributing resources equally across transportation projects or relying exclusively on conventional financial measures.

For road transportation, traffic volume and characteristics or transportation demand emerged as a significant positive predictor of investment, with the largest standardized coefficient among the variables reported in the regression table ($\beta = 0.309$, $p = 0.049$). This result indicates that actual and anticipated use of the road network is a central consideration in investment decisions. Roads serving large traffic flows, rapidly growing urban areas, freight corridors, border crossings, or areas with unmet mobility demand are more likely to generate visible economic and social returns. High traffic volume can support investment by demonstrating the need for additional capacity and the potential for reduced travel time, congestion, and logistics costs. It can also improve the feasibility of toll roads and other revenue-generating arrangements. This demand-based interpretation is consistent with research on public–private partnership projects, in which demand uncertainty, revenue forecasts, contractual allocation of risk, and long-term project obligations constitute major determinants of investment viability [12].

The significance of road transportation demand also suggests that investment planning should be based on reliable operational data rather than solely on administrative preferences or the physical condition of infrastructure. Traffic counts, freight flows, passenger movements, origin–destination patterns, and projected economic activity can help distinguish projects that address genuine mobility constraints from those with weak utilization prospects. At the same time, road safety conditions did not independently predict the overall investment score in the regression model, despite their conceptual importance and their inclusion among the priority road variables. This does not imply that safety is unimportant. Instead, it may indicate that safety considerations are already incorporated into traffic demand, design standards, regulatory requirements, and project appraisal, or that experts perceive safety as a mandatory condition rather than an independent source of investment attractiveness. The broader literature similarly shows that transportation performance should not be evaluated through financial variables alone and that nonfinancial measures are needed to capture service quality, safety, operational effectiveness, and stakeholder outcomes [11].

In maritime transportation, freight transportation revenue was a significant predictor of investment ($\beta = 0.092$, $p = 0.023$). Maritime facilities are highly capital intensive and require continuous expenditure on ports, terminals, loading equipment, navigation systems, dredging, storage facilities, and hinterland connections. Freight revenue provides a direct indication of commercial activity and the ability of maritime infrastructure to generate cash flows sufficient to justify investment, maintenance, and modernization. This finding is consistent with the importance of financial transparency in capital-intensive transportation systems. When revenues, costs, liabilities, subsidies, and operational performance are clearly disclosed, investors and public authorities can assess project viability more accurately and allocate resources more efficiently [10]. Transparent

revenue information may be particularly important in developing countries, where uncertainty about institutional performance and financial reporting can raise the perceived risk of long-term infrastructure investments.

The importance of maritime freight revenue also aligns with the argument that sustainable financing strategies must be connected to the economic and operational realities of the maritime sector. Sustainable financing cannot be maintained unless environmental and social obligations are supported by dependable income streams, credible governance, and appropriate financial mechanisms [2]. Similarly, supply-chain finance can facilitate the circulation of capital, strengthen cooperation among supply-chain participants, and support breakthrough green innovation through knowledge spillovers from core firms [4]. In the maritime context, stronger freight revenues may therefore do more than improve short-term profitability: they may provide ports and shipping companies with the capacity to renew equipment, adopt cleaner technologies, improve energy efficiency, and finance environmentally responsible operating systems.

The factor-prioritization stage also identified the quality and quantity of vessels and ships—including their type, age, number, and utilization—as an important maritime investment consideration. Fleet capacity determines whether the maritime system can respond to trade demand, maintain service frequency, control operating costs, and comply with safety and environmental standards. Older or unsuitable vessels may create higher maintenance expenses, fuel consumption, emissions, and accident risks, thereby reducing investment attractiveness. Although the marine-environment variable did not have an independent statistically significant coefficient in the final regression table, environmental performance remains closely connected to vessel characteristics and fleet renewal. Previous research has shown that the financing of water-protection measures in transportation can affect the quality of water bodies, demonstrating that transportation investment decisions have consequences extending beyond immediate financial returns [5]. Thus, the nonsignificant direct coefficient for the marine environment may reflect its integration into fleet quality, regulatory compliance, and infrastructure modernization rather than an absence of environmental importance.

For rail transportation, the length of main railway lines was a significant positive predictor of investment ($\beta = 0.234$, $p = 0.041$). This finding highlights network coverage as a fundamental source of rail value. A longer and better-connected main-line network can improve access to markets, strengthen links among industrial centers, ports, border crossings, and population centers, and create economies of scale. Network expansion can also increase the strategic value of existing stations, rolling stock, terminals, and logistics facilities. The result therefore suggests that rail investment should be evaluated at the network level rather than as a collection of isolated projects. A new line becomes more attractive when it closes a missing link, connects productive regions, or increases the utilization of existing infrastructure.

In contrast, the number of passengers or passenger-kilometers and current rail expenditure did not have statistically significant independent effects. One possible explanation is that current passenger activity reflects the present condition of the system but does not necessarily represent its long-term investment potential. Existing passenger volumes may be constrained by insufficient coverage, poor service quality, low speeds, or competition from road transportation. Likewise, current expenditure may capture routine operational costs without indicating whether spending produces additional capacity or productivity. The financial vulnerability of transportation and logistics firms during periods of disruption demonstrates why historical expenditure or short-term activity should not automatically be interpreted as evidence of investment strength [6]. Capital structure must also be managed according to organizational and sectoral development conditions, because financing needs and debt capacity can change throughout a company's life cycle [8].

In air transportation, infrastructure resources were a significant positive predictor of investment ($\beta = 0.175$, $p = 0.041$), confirming that airport capacity and supporting facilities influence the attractiveness of aviation investment. Air transportation depends on integrated infrastructure, including runways, terminals, navigation systems, security equipment, ground services, access roads, energy systems, and specialized maintenance facilities. Deficiencies in any of these components can constrain the productivity of the entire airport. Investment in aviation should therefore consider the completeness and compatibility of the infrastructure system rather than focusing on a single physical asset. The coefficient table also showed a significant positive effect for air safety ($\beta = 0.111$, $p = 0.033$), indicating that experts associate safer aviation environments with stronger investment prospects. Safety can preserve passenger confidence, reduce operational

disruptions and liabilities, and enhance the credibility of airports and airlines.

The importance of infrastructure and safety in aviation is also related to technological capability. Contemporary transportation systems increasingly depend on digital platforms, automated monitoring, real-time information, and data-based asset management. Research on digital transformation in the national transportation sector emphasizes intellectual capital, organizational knowledge, and institutional capability as foundations for successful technological change [13]. Accordingly, physical aviation infrastructure should be complemented by investment in specialist knowledge, digital control systems, and organizational learning. However, digitalization also creates regulatory and governance challenges. Studies of transportation network companies demonstrate that technological platforms can alter market structures and require policy adaptation to address competition, accountability, labor, and public-interest concerns [14]. Infrastructure investment should consequently be coordinated with digital governance and regulatory capacity.

Several variables—including direct financial resources and credit for roads, rail passenger activity, rail current expenditure, air maintenance and operation services, road safety conditions, and the marine environment—were not independently significant in the final model. These results should not be interpreted as evidence that the variables can be ignored. Their effects may be indirect, shared with stronger predictors, or dependent on institutional conditions. Financial resources, for example, are essential for investment, but access to finance alone cannot make a project viable when demand, revenue, connectivity, or infrastructure capacity is insufficient. Financial competence also affects how resources are evaluated and allocated. Evidence on financial literacy demonstrates the importance of financial knowledge for informed decisions in transportation-related economic and social contexts [9]. The findings therefore suggest that financing should be treated as an enabling mechanism whose effectiveness depends on the quality of the underlying transportation project.

The results also reinforce the value of integrating financial and nonfinancial performance. Evidence from transportation and logistics firms indicates that sustainability and financial performance are connected and may be influenced by governance characteristics such as board gender diversity [7]. Consequently, the significant predictors identified in this study should not be used as a narrow checklist focused only on demand and revenue. They should be incorporated into a broader appraisal system that considers environmental sustainability, safety, governance, resilience, and social value. Ethical capital is also relevant because public confidence, responsible leadership, organizational values, and professional education can influence how transportation organizations manage public resources and stakeholder interests [15]. Investment strategies are more likely to remain legitimate and sustainable when economic priorities are supported by transparent and ethical decision-making.

Overall, the findings show that investment attractiveness differs across transportation modes but is consistently connected to the ability of infrastructure to serve demand, generate economic activity, extend network capacity, and maintain operational quality. Road investment is primarily demand-sensitive; maritime investment depends strongly on freight revenue and fleet capability; rail investment is shaped by the extent and connectivity of main lines; and air transportation investment is supported by infrastructure resources and safety. These results favor an integrated but mode-specific approach to macro transportation planning. They also show that sustainable transportation finance should combine commercial feasibility with environmental responsibility, institutional transparency, technological capacity, and stakeholder-oriented governance [2, 4, 7]. The study therefore contributes a practical prioritization framework that can help developing countries direct limited investment toward the transportation factors most likely to produce system-wide benefits.

This study has several limitations. The sample consisted of 60 specialists and was concentrated within a specific national and regional context, which may limit the generalizability of the findings to all developing countries. The data were based primarily on expert judgments and may therefore be affected by respondents' professional backgrounds, institutional affiliations, or subjective perceptions. The cross-sectional design also prevented the study from examining changes in investment priorities over time. In addition, some potentially relevant macroeconomic, political, regulatory, and geopolitical variables were not included in the final model. The estimated relationships should consequently be interpreted as expert-based associations rather than definitive causal effects.

Future studies should test the proposed framework with larger and more geographically diverse samples drawn from several developing countries. Longitudinal research could examine how investment priorities change during economic crises, technological transitions, policy reforms, or major

disruptions. Researchers could also compare public-sector officials, private investors, transportation operators, and service users to identify differences among stakeholder perspectives. Additional variables—including inflation, exchange-rate volatility, political stability, regulatory quality, climate risk, accessibility, social equity, and institutional transparency—could be incorporated. Structural equation modeling, system-dynamics analysis, scenario planning, and longitudinal panel models may further clarify direct, indirect, and reciprocal relationships among transportation investment factors.

Policymakers should establish a multimodal investment-evaluation system that applies mode-specific indicators while maintaining common standards for economic, environmental, safety, and social performance. Road projects should be supported by verified traffic and demand data; maritime investments should be connected to freight-revenue potential and fleet-renewal requirements; rail projects should prioritize network connectivity and the development of strategically important main lines; and aviation projects should combine infrastructure improvements with rigorous safety management. Authorities should also improve financial disclosure, develop reliable transportation databases, conduct periodic asset-condition assessments, and establish transparent project-selection procedures. Public and private financing should be directed toward projects that demonstrate measurable demand, long-term operational viability, and compatibility with national transportation and sustainable-development objectives.

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Authors equally contributed to this article.

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Declaration of Interest

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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