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RESEARCH ARTICLE

Approaches to Develop Service Quality of Road Freight Transport Service Providers in Industrial 4.0

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ABSTRACT

High-quality service provision in road freight transport results in a management system that meets established standards. This research aims to enhance the service quality of road freight transport service providers and develop this enhancement into a structural equation model. The study employs both qualitative and quantitative methodologies, involving nine experts and eleven qualified professionals. It also includes a quantitative survey of 500 executives in the industry who have achieved the Q Mark standard for transport services. The research utilizes descriptive statistics, inferential statistics, and multivariate statistics. The study identified four key components of service quality development for road freight transport service providers in Industrial 4.0, ranked by importance: 1) Business Strategy (Mean = 4.30): The most critical elements include clear and easily understood operational planning and processes. 2) Smart Operations (Mean = 4.15): The highest priority is the daily readiness of vehicles, monitored through GPS tracking to ensure consistent availability. 3) Customer Relationships (Mean = 4.11): The most crucial aspect is the management of digital customer history data (via Dropbox), which helps solve problems related to the appropriate storage of customer information. 4) Personnel Capabilities (Mean = 3.95): Key factors include defining employee qualifications, recruitment, capability assessment, and aligning attitudes with business needs. The hypothesis testing revealed that small and medium-sized enterprises differ significantly at the 0.05 level in their emphasis on the development of service quality approaches for road freight transport in the Industrial 4.0 era. Analysis of the developed structural equation model indicated that it meets the assessment criteria and is consistent with empirical data. The model showed a Chi-square probability level of 0.187, a relative Chi-square value of 1.092, a goodness-of-fit index of 0.964, and a root mean square error of approximation (RMSEA) of 0.014, all indicating statistical significance.

INTRODUCTION

Amid the transformative shifts brought about by Industrial 4.0, road freight transportation emerges as a predominant mode, accounting for more than 80% of all transport activities in the country. This sector is integral to economic, social, and political endeavors, largely due to its capability to offer door-to-door accessibility. The current global and national disruptions necessitate an adaptive response from the road freight sector to these changes.

There is an urgent need to improve the quality of road freight services to ensure they are flexible and capable of adapting to the changing demands and trends of the industry. These improvements are crucial not only for helping service flexibility but also for efficiently meeting customer needs and strengthening the competitive position of road freight businesses, both domestically and internationally. The study of registration trends for road freight transport service providers indicates a steady increase.

In 2022, there were 85,022 registered providers, reflecting a significant growth of 9.82%. By 2023, the number of registered road freight transport service providers had risen to 85,081, marking a slight increase of 0.07%. Moreover, this data has been correlated with the business dataset of road freight service providers that have received the Q Mark standard for quality service in truck transportation (Truck Data Service Center, Department of Land Transport, 2023).

This standard is a tool for developing and promoting quality and standardization in service delivery and allows operators to compete effectively in the free trade freight transport market. This standard is a tool for developing and promoting quality and standardization in service delivery, allowing operators to compete in the free trade freight transport market. The usage of the truck transport quality service standard system as a means to increase the capabilities of transport operators has shown that the number of newly certified Q Mark operators in 2023 decreased by an average of 43.00%, according to the dataset of Q Mark certified operators. When comparing the number of Q Mark-certified operators to the total number of registered operators, a ratio of 1:42 was identified. This gap focuses on the various service quality among road freight service providers, contributing to competitive disadvantages for some operators in the industry.

Objectives

1. To study the structure and operational characteristics of road freight transport businesses in the era of Industrial 4.0.
2. To examine the components of quality service development approaches for road freight transport service providers in the era of Industrial 4.0.
3. To develop a structural equation model for the quality service development approaches of road freight transport service providers in the era of Industrial 4.0.

LITERATURE REVIEW

The researcher investigated concepts and theories from various documents and textbooks related to Business Strategy, Smart Operation, Personnel Competencies, and Customer Relationships, as follows:

1. Concepts Related to Business Strategy

Business Strategy involves creating competitive advantages to drive an organization towards its goals. This encompasses critical decisions about growth strategies, establishing new core businesses, identifying new operational tools, allocating resources, and achieving cost efficiency. This strategy covers five main approaches: 1) Cost Leadership Strategy: This strategy focuses on producing goods at a lower cost than competitors, which allows an organization to set product prices in the market and be a price leader. 2)

Differentiation Strategy: This strategy involves finding a new market position for the organization where there are no competitors or only a few competitors. The aim is to create appeal and generate interest among new customer groups. 3) Customer-Centric Strategy: This strategy focuses on responding to the needs of customers, emphasizing primarily their requirements from the initial stages of business planning through to the production or service processes. It aims to adapt continuously to meet the evolving needs of customers. 4) Niche Market Strategy: This strategy involves identifying a specific customer group with unique needs. The advantage is that it allows the

organization to develop a distinct identity and face less competition. 5) Cost Focus Strategy: This strategy concentrates on selling to a specifically targeted group The study of concepts related to Business Strategy includes insights on organizational management (Organization Management) detailed by Suthee (2016: 9-15), the strategic concept of the Blue Ocean Strategy by W. Chan Kim (2005), the management theory (POCCC) by Henri Fayol (1916), the tool for analyzing external factors (PESTEL Analysis) by Arnold Brown (1980), and the Five Forces Model by Michael E. Porter (1980).

2. Concepts Related to Smart Operation

Smart Operation refers to systems that enhance the use of intelligent control systems to help manage operations. These systems facilitate the swift execution of commands, thereby elevating organizational capabilities. For instance, automated production systems, intelligent administrative management systems for organizational operations (equipment and facilities), and intelligent support systems (facilities) aim to create systems that operate intelligently.

These systems manage and adapt autonomously, process and analyze data, and allow for agile and coordinated operations. This enables the creation of seamless data transmission networks, facilitating the automatic and immediate execution of system commands. The study of concepts related to Smart Operation includes the Value Chain concept (Michael E. Porter, 1985) and the Balanced Scorecard (Kaplan & Norton, 1990).

3. Concepts Related to Personnel Competencies

Competency is a crucial factor that enhances the competitive ability of an organization, particularly in the management of human resources. Competencies help develop the potential of personnel, leading to organizational development. Organizations strive to use competencies as a key factor in various aspects of management, such as human resource management, curriculum development, service work enhancement, or leadership development for executives.

The study of concepts related to Personnel Competencies includes the McKinsey 7s framework (Tom Peters and Robert Waterman, 1980) and the Competency theory (Mc Clelland, 1973). The concept of Service Quality)Parasuraman, Berry, and Zeithaml,1988) arises from interactions between consumers and service employees, products, or the provider's systems (Gronroos, 1990). Good service quality should be flawless, recognizing and fulfilling the needs of consumers (Kitapci, Akdogan, & Dortyol, 2014). Service quality differentiates businesses and can elevate a business above its competitors. Providers should consider the desires, feelings, or any aspect that satisfies and impresses customers, making them always remember the product or service, leading to customer loyalty (Natthapat, 2006, p. 12).

Parasuraman, Zeithaml, and Berry (1985) developed a tool for assessing customer perceptions of service quality in service and retail businesses, known as SERVQUAL. This tool, famous for its efficacy, initially proposed several criteria but was later refined to five broad criteria due to a high degree of correlation among the original factors. These criteria are Tangibles, Reliability, Responsiveness, Assurance, and Empathy, as further refined by Zeithaml, Bitner, & Gremler (2006).

4. Concepts Related to Customer Relationships

Building strong customer relationships is a key aspect of Relationship Marketing, a strategy that aims to create long-term value for your brand and business. This method focuses on customer satisfaction by concentrating on product development, service quality, after-sales service, and marketing activities that create positive customer experiences, which will eventually lead to customer loyalty. The concept of "Human Relations Management", especially the studies by Elton Mayo, is often

referred to as the "Father of Human Relations Management" (Yaron J. and Jeff M., 2019, cited in Elton Mayo, 1927-1932), is best known for the "Hawthorne Experiment."

This study analyzed workers' attitudes and psychology in different work environments, with a special focus on management practices and leadership. The results show that humans are emotional beings and that building team spirit is crucial for effective work. It also stressed the importance of behavioral science, organizational roles and functions, social status, symbols of status, and the influence of informal groups within an organization. This strategy is the key to understanding an organization as a social system powered by human interactions.

RESEARCH METHODOLOGY

This study is an “Inductive Research” using a mixed-method technique which includes three following components:

1) Qualitative research by using in-depth interviews technique.
2) Quantitative research by using survey methods, and
3) Qualitative research by using focus group discussions to confirm the validity of the research model.

Population and Sample for the Research

1. The qualitative research with in-depth interviews uses a sample of 9 experts, selected through purposive sampling. These qualified experts were defined by the Doctor of Business Administration program in Industrial Business Administration at the Faculty of Business Administration, King Mongkut's University of Technology North Bangkok. The experts were separated into three groups which are: individuals from industry businesses or organizational management 3 people, government and related agencies 3 people, and academics 3 people.
2. The quantitative research using “Survey Method” techniques, the population for this section was determined to be 1,889 road freight transport service providers (Department of Business Development, 2023), including medium and small-sized road freight transport businesses classifications based on the Promotion of Small and Medium Enterprises Act (Service Sector), (2000).
3. The sample size was determined using criteria from research involving component analysis or structural equation modeling, which has an optimal sample size of 500 samples (Thanin, 2024). A Multi-Stage Sampling method was used (Thanin, 2024), including Cluster Sampling, which separated the road freight transport service providers into two categories which are: medium and small-sized businesses. Probability sampling was then conducted using the lottery method to select the samples.
4. Qualitative Research Using Focus Group Discussion: To validate the research model, qualitative research was conducted using focus group discussions. The sample consisted of 11 experts in the road freight transport service sector, selected through purposive sampling based on the qualifications defined by the Doctor of Business Administration program in Industrial Business Administration at the Faculty of Business Administration, King Mongkut's University of Technology North Bangkok. These experts were distinct from those involved in the in-depth interview phase of the qualitative research.

Research Results

The analysis of the structural equation model for the development of service quality approaches for road freight transport service providers in the Industrial 4.0 era was conducted using both Unstandardized Estimate and Standardized Estimate modes after model adjustments.

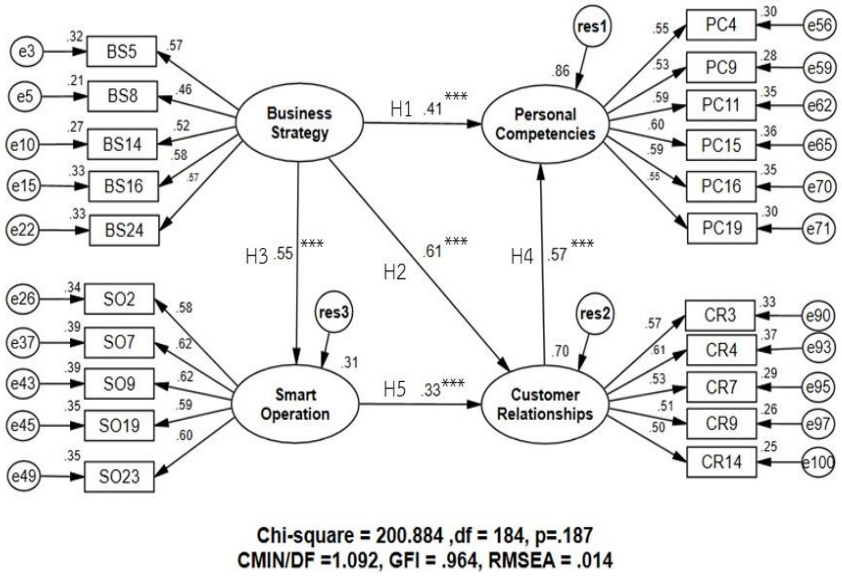

Figure 1. Structural equation model for the development of service quality approaches for road freight transport service providers in the Industrial 4.0 era, shown in Standardized Estimate mode after model adjustments.

Table 1: Statistical values derived from the analysis of the structural equation model after model adjustments.

Variables	Estimate		R^2	Variance	C.R.	P
	Standard	Unstandardized				
Business Strategy				0.15		
Customer Relationships	0.61	0.61	0.70	0.05	6.55	***
Personal Competencies	0.41	0.42	0.86	0.02	3.56	***
Smart Operation	0.55	0.62	0.31	0.13	6.91	***
Smart Operation				0.13		
Customer Relationships	0.33	0.29	0.70	0.05	4.36	***
Customer Relationships				0.05		
Personal Competencies	0.57	0.57	0.86	0.02	4.72	***
Business Strategy				0.15		
BS5	0.32	1.00	0.32	0.32		
BS8	0.46	0.92	0.21	0.47	8.03	***
BS14	0.52	0.93	0.27	0.35	8.78	***
BS16	0.58	1.02	0.33	0.31	9.42	***
BS24	0.57	1.00	0.33	0.31	9.39	***
Customer Relationships						
CR3	0.57	1.00	0.33	0.32		
CR4	0.61	1.12	0.37	0.33	10.09	***
CR7	0.53	0.99	0.29	0.37	9.22	***

CR9	0.51	0.94	0.26	0.37	8.97	***
CR14	0.50	0.95	0.25	0.40	8.84	***
Smart Operation						
SO2	0.58	1.00	0.34	0.38		
SO7	0.62	1.09	0.39	0.36	9.91	***
SO9	0.62	1.13	0.39	0.39	9.88	***
SO19	0.59	1.06	0.35	0.40	9.61	***
SO23	0.60	1.02	0.35	0.37	9.63	***
Personal Competencies						
PC4	0.55	1.00	0.30	0.36		
PC9	0.53	0.95	0.28	0.35	9.13	***
PC11	0.59	1.06	0.35	0.33	9.79	***
PC15	0.60	1.08	0.36	0.32	9.91	***
PC16	0.59	1.06	0.35	0.32	9.84	***
PC19	0.55	1.01	0.30	0.37	8.84	***

***** Statistically significant at the 0.001 level**

From Figure 1 and Table 1, it is evident that the structural equation model for developing service quality approaches for road freight transport service providers in the Industrial 4.0 era, after model adjustments, consists of four latent variables. These include one exogenous latent variable, which is Business Strategy, and three endogenous latent variables: Smart Operation, Personal Competencies, and Customer Relationships.

The Business Strategy component comprises five observed variables, listed in order of their standardized regression weights from highest to lowest as follows:

1) BS5: Having a clear organizational structure that defines authority and responsibilities.

2) BS8: Promoting the organization's attainment of international quality standards in various operations, such as ISO 9000, ISO 14000, ISO 39001, and ISO 18000.

3) BS14: Implementing performance indicators for road transport operations, with real-time display and monitoring.

4) BS16: Planning risk management strategies to minimize the loss of organizational goals.

5) BS24: Developing appropriate personnel operational plans, including systematic and documented procedures.

The Smart Operation component consists of five observed variables, listed in order of their standardized regression weights from highest to lowest as follows:

1) SO2, Implementing the Truck Platooning System technology to control operations.

2) SO7, Presenting operational performance data through a dashboard.

3) SO9, install an alert system for managing waste generated from road freight transport.

4) SO19, Using Vehicle-to-Vehicle Communication (V2V) during service operations to connect systems that reduce risks and accidents, as well as to share traffic information, route positions, and speed capabilities.

5) SO23, Implementing the Traveling Salesman Problem (TSP) system to optimize routing and scheduling for road freight transport.

The customer relationships component consists of five observed variables, ranked by their standardized regression weights from highest to lowest respectively as follows:

1) CR3: Establishing channels for receiving feedback from customers and external parties, with proper recording and storage.

2) CR4: Segmenting the organization's target groups into clusters with similar interests to enhance organizational efficiency.

3) CR7: Building relationships through Customer Relationship Management (CRM) systems to improve operational efficiency.

4) CR9: Engaging in interactions with customers to discover and understand their needs.

5) CR14: Developing techniques to create a positive impression and memorable experiences for customers through Customer Experience Management (CEM).

The Personal Competencies component consists of six observed variables, ranked by their standardized regression weights from highest to lowest as follows:

1) PC4: Conducting random checks on the work methods of employees during and after the operations of transport drivers.

2) PC9: Providing in-house driving license exams for company drivers to facilitate their convenience.

3) PC11: Offering professional development training for road transport drivers (Professional Driver).

4) PC15: Promoting discipline, morality, ethics, and preventing disciplinary violations among employees.

5) PC16: Implementing dress code regulations for drivers and establishing appropriate penalties for non-compliance.

The hypothesis testing results for analyzing the causal relationships between latent variables in the structural equation model for developing service quality for road freight transport providers in the Industrial 4.0 era encompass five hypotheses as follows:

H1: Business Strategy has a direct influence on Personal Competencies.

The hypothesis testing results show that Business Strategy directly influences Personal Competencies, with a Standardized Regression Weight of 0.41 and statistical significance at the 0.001 level, consistent with the research hypothesis.

H2: Business Strategy has a direct influence on Customer Relationships.

The hypothesis testing results show that Business Strategy directly influences Customer Relationships, with a Standardized Regression Weight of 0.61 and statistical significance at the 0.001 level, consistent with the research hypothesis.

H3: Business Strategy has a direct influence on Smart Operation.

The hypothesis testing results found that Business Strategy directly impacts Smart Operation, with a Standardized Regression Weight of 0.55 and statistical significance at the 0.001 level, supporting the research hypothesis.

H4: Customer Relationships have a direct influence on Personal Competencies.

The hypothesis testing results show that Customer Relationships directly influence Personal Competencies, with a Standardized Regression Weight of 0.57 and statistical significance at the 0.001 level, supporting the research hypothesis.

H5: Business Strategy has a direct influence on Customer Relationships.

The hypothesis testing results indicate that Business Strategy has a direct influence on Customer Relationships, with statistical significance at the 0.001 level. The Standardized Regression Weight is 0.61, which aligns with the research hypothesis.

DISCUSSION

The key points derived from the research on strategies for enhancing the quality of service provided by road freight transport service providers in the era of Industrial 4.0 highlight the need for effective management practices and adherence to service standards. These strategies are crucial for increasing competitiveness both domestically and internationally. Based on the results of this research, the researcher has conducted a discussion to reach conclusive insights. This discussion incorporates references to relevant research documents that either support or challenge the findings, as outlined in the following five points:

The research findings indicate that the component with the highest average score is the Business Strategy component, with an average value of 4.30. The empirical data emphasizes the critical role of Business Strategy in increasing the quality of service provided by road freight transport service providers in the industry 4.0 era, consistent with multiple studies. Among the key elements, clear and easily understandable operational plans and processes are the most crucial for improving service quality. Hypothesis testing shows that Business Strategy significantly influences both Customer Relationships and Personal Competencies, concentrating on the importance of clear strategies, consistent quality, and effective organizational management. These factors are essential for the future success and long-term commercial networks of road freight carriers. Properly developed operational plans and well-defined written procedures are expected to enhance employee performance effectively and efficiently. This finding aligns with the research conducted by Paula Apascaritei, Marta M. Elvira, María Rodríguez-García (2024), and Philomena Ify Igbokwe (2024). The hypothesis testing results reveal that the overall approach to improving the quality of service provided by road freight transport service providers in the Industrial 4.0 era varies significantly according to business size, with statistical significance at the 0.05 level. Medium-sized enterprises place more emphasis on developing service quality than small businesses, with statistical significance at the 0.05 level. This finding aligns with the research conducted by Filip Fors Connolly, Ingemar Johansson Seva, and Tommy Garling (2021).

CONCLUSION

The researcher presents an overview of the development of service quality approaches for road freight transport service providers in the Industrial 4.0 era, followed by the research conclusions outlined below.

The analysis of service quality development approaches for road freight transport service providers in the Industrial 4.0 era, conducted through qualitative research using in-depth interviews with experts, identified four key components. These components are Business Strategy, Smart Operation, Personal Competencies, and Customer Relationships, totaling 100 items, with each component comprising 25 variables, respectively.

The general status of industrial business organizations reveals that the respondents were evenly split between small and medium-sized enterprises (each constituting 50%). The majority of businesses were registered as limited companies (78.80%). Most of these businesses were involved in the consumer goods industry (32.40%), and a significant portion had been operating for more than 10 years (71.60%).

The structure and operational characteristics of road freight transport service providers in the Industrial 4.0 era reveal that:

1) Organizations place significant emphasis on the use of information technology, particularly GPS tracking systems (81.00%). 2) Organizations have established liability limits for product damage during transport, with coverage up to the value of the goods (59.00%).

3) Organizations utilize Total Quality Management (TQM) as a tool for operational improvement (51.40%). 4) Organizations adhere to the Quality Mark (Q Mark) standard for truck transport services (76.00%). 5) Additionally, organizations provide warehouse services (33.60%). 6) Furthermore, organizations place importance on improving transport operations by implementing speed control measures for road freight vehicles (44.60%). 7) Organizations also utilize location and route navigation systems, such as Google Maps (55.00%). 8) Additionally, organizations have established emergency management plans (Emergency Plan) and regularly review these plans (52.60%). 9) Organizations emphasize defining employee qualifications, recruitment, hiring, capability assessment, and attitude evaluation (55.00%). 10) Organizations prioritize health check-ups for drivers (43.60%). 11) They also emphasize training in defensive driving to prevent accidents (59.80%). 12) Organizations place importance on employee welfare (49.20%). 13) They focus on planning energy-efficient transportation operations (37.40%). 14) Appropriate measures, such as speed limits, are implemented (47.60%). 15) The predominant mode of transport is Full Truck Load (FTL) (85.40%). 16) Organizations set qualifications for good drivers, particularly in terms of attention (43.60%). 17) Driver wages and compensation is primarily within the range of 15,001 – 25,000 baht (60.40%). 18) For trip monitoring, most organizations use GPS to check speed and current vehicle location (76.00%). 19) The majority of organizations emphasize the safety management of general cargo by securing and fastening goods on trucks (44.20%). 20) Customer satisfaction is evaluated through overall satisfaction (attitude) measurements (65.00%). 21) Feedback from customers and external parties is primarily received via telephone (41.20%). 22) Organizations prioritize quick response to customer needs (53.60%) and hold regular and continuous meetings with customers (35.60%).

The significance level of the components in the approach to improving the service quality of road freight transport service providers in the Industrial 4.0 era is generally high, with an average score of 4.13. When examining each component of the service quality improvement approach for road freight transport service providers in the Industrial 4.0 era, the results can be ranked as follows:

1) Business Strategy is of high importance, with an average score of 4.30.

2) Smart Operation is also highly important, with an average score of 4.15.

3) Customer Relationships hold significant importance, with an average score of 4.11.

4) Personal Competencies are important, with an average score of 3.95, respectively.

The comparison of the significance levels of the components in the approach to improving the service quality of road freight transport service providers in the Industrial 4.0 era, categorized by industry business size, was conducted using an independent samples t-test. The results indicate that the overall importance of these components, when categorized by business size, shows a statistically significant difference at the 0.05 level. Specifically, medium-sized businesses place greater

importance on the approach to improving the service quality of road freight transport service providers in the Industrial 4.0 era compared to small-sized businesses.

Suggestions

1. For Policy-Level

1) The Department of Land Transport, and the Ministry of Transport, should establish regulations and guidelines for implementing automation technology for matching trucks with cargo owners (Automation Matching: AI) to enhance road freight transportation.

2) The Department of Skills Development, Ministry of Labour, should establish accredited driving schools to improve competitiveness both domestically and internationally.

3) The Energy Policy and Planning Office (EPPO), Ministry of Energy, should liberalize the import of fuel to provide alternatives for reducing road transportation costs in Thailand.

4) The Ministry of Higher Education, Science, Research, and Innovation should promote, support, and oversee educational programs related to truck drivers, focusing on producing and developing a workforce that meets the country's needs.

2. For Operational-Level

1) Road freight transport service providers should focus on developing clear and straightforward operational plans and processes, including appropriate vehicle categorization based on the type of transportation.

2) Road freight transport service providers should regularly inspect vehicle readiness and utilize GPS tracking systems before each road transportation service.

3) Road freight transport service providers should implement a digital customer data management system (e.g., Dropbox) to address issues related to customer data storage, ensure proper management, and retain existing customers against competitors.

4) Road freight transport service providers should establish clear criteria for employee qualifications, recruitment, capability assessment, and attitude evaluation to align with business needs.

5) Road freight transport service providers should employ personnel responsible for Transport Safety Management (TSM) to plan, oversee, and ensure safety in transportation operations.

6) Road freight transport service providers should award outstanding truck drivers to motivate and recognize employees who have never received complaints, enhancing the professional image of the industry.

7) Road freight transport service providers should build networks and partnerships with potential business collaborators, including knowledge and experience exchange, to foster sustainable cooperation.

3. For Future Research

1) Explore methods for enhancing the standards of road freight transport service providers through the Quality Service Mark (Q Mark) to support safety in road transportation.

2) Investigate strategies for preparing road freight operators to meet quality service standards in the digital era of Thailand.

3) Examine approaches to implementing Green Transportation practices and their impact on the operations of road freight service providers.

4) Develop strategies for advancing medium-sized and small road freight enterprises (SMEs) to adapt to digital-era transportation requirements and national changes.

5) Analyze methods for transitioning from traditional trucking to multimodal transport, incorporating rail transport for improved efficiency.

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