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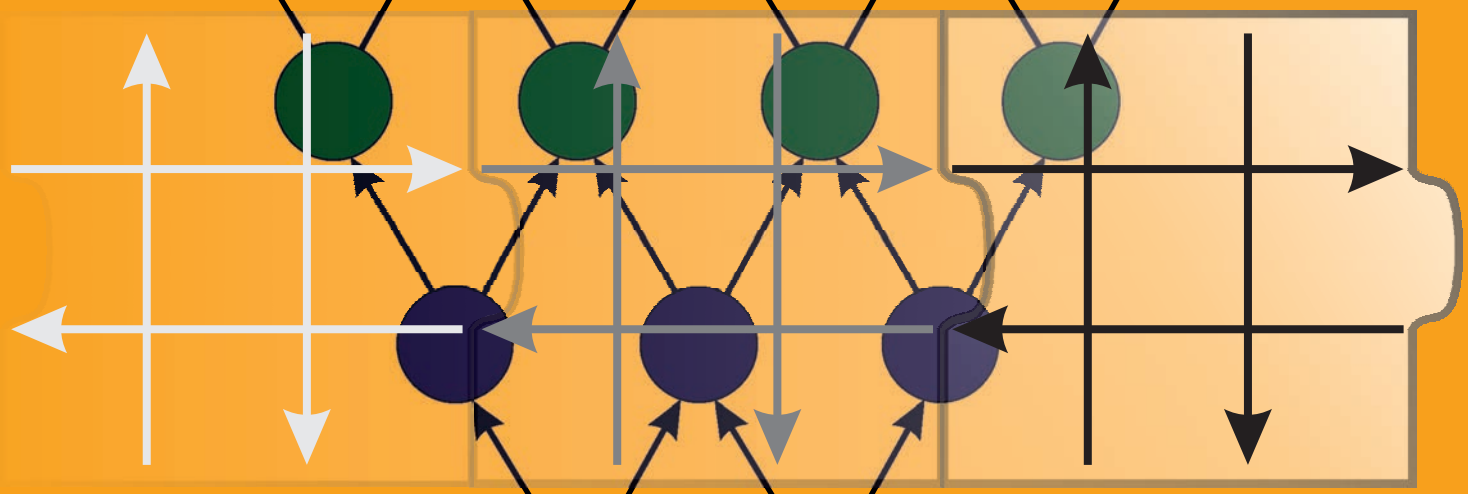

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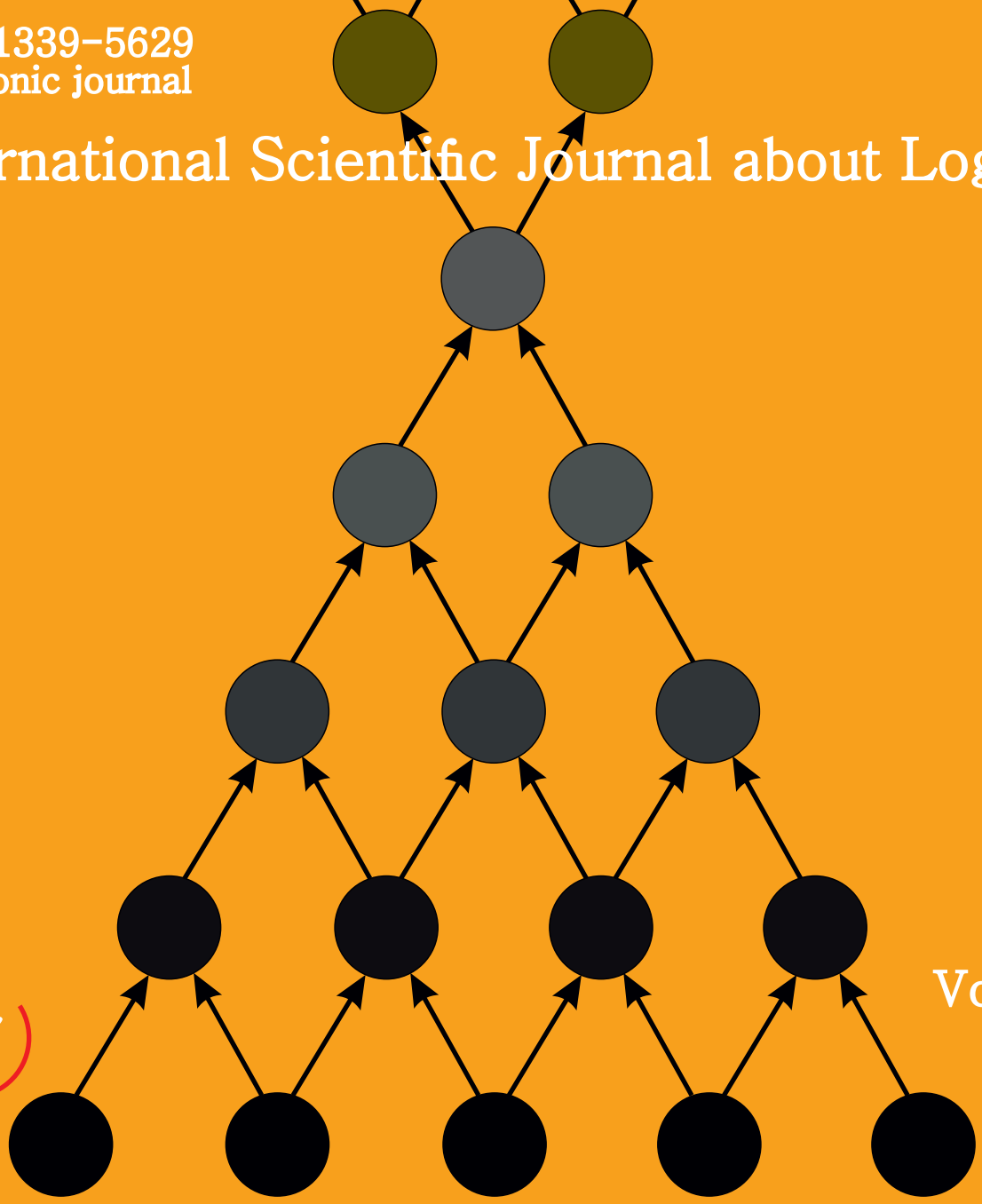

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INTANGIBLE ASSETS IN MODERN TRANSNATIONAL CORPORATIONS IN SERVICE INDUSTRY

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Keywords: transnational corporations, world economy, intangible assets, service sector, service logistics.
Abstract: An analysis of the activities of leading transnational corporations (TNCs) for the period from 2000 to 2020 showed that the transformation of the world economic order leads not only to new rules for conducting international business, but also to the occupation of prevailing positions in the world market by TNCs engaged in the service sector. Therefore, the purpose of the study was a systematic analysis of the impact of intangible assets on the growth of the competitiveness of the service sector and the increase in their market capitalization, revenue and asset value. Based on an in-depth study of statistical data, the authors identified trends that led to an increase in the share of intangible assets in the value of companies; an analysis was made of the presence of TNCs in the service sector in the ratings for assessing the level of revenue and market capitalization (based on the Fortune Global 500); comparison of indicators related to intangible assets with the human development index and the business environment, formed taking into account the existing investment climate (based on AON Empower Results, GIFT, World Investment Report); identified the most promising sectors for the use of intangible assets. Based on the results of the study, uniform principles were formed according to which the management of intangible assets of TNCs should take place, in which an important place is occupied by the use of the potential of intangible assets and the advantages of the triple helix of innovations (education - business - government).

1 Introduction

Due to increasing globalization, the beginning of the XXI century was marked by the emergence of a large number of transnational companies that dominated almost all industries. At the same time, they face the increasing need both to maintain their existing competitive advantages and to form new ones based on emerging trends inherent in the entire global market, including: changing market conditions and business models, rapid digitalization and new forms of globalization, change in technological patterns and transition to a new stage of the industrial revolution.

One of their features is increased role of intangible assets, including those that make up a significant part of the value of modern companies. About 40 years ago, according to AON and LLC Ponemon Institute experts, the share of intangible assets in the value of companies included in the Standard & Poor's (S&P) 500 index was about 17% (122 mil. USD); currently it exceeds 85% (21 tril. USD) (Table 1).

Table 1 Share of tangible and intangible assets in S&P 500 companies

Period	Index	Intangible assets	Tangible assets
1975	Share, %	17	83
1985	Share, %	32	68
	Rising cost	+ 360 bil. USD	+ 471 bil. USD
1995	Share, %	68	32
	Rising cost	+ 2 638 bil. USD	+ 450 bil. USD
2005	Share, %	80	20
	Rising cost	+ 6 160 bil. USD	+ 850 bil. USD
2018	Share, %	84	16
	Rising cost	+ 11 750 bil. USD	+ 1 680 bil. USD
2020	Share, %	90	10
	Rising cost*	+ 8 000 bil. USD	+ 1 000 bil. USD

** preliminary estimates*
Source: compiled by the authors according to AON Empower Results [1]

Despite this, accounting for intangible assets and the degree of data disclosure about them by companies still remains a problem. Experts have different ideas about what is included in intangible assets. In Russia since 2021, the Federal Accounting Standard for Public Finance 'Intangible Assets' is in force, changing the accounting procedure and fixing the main criteria under which an object can be equated to an intangible asset. At the same time, the question of the very 'subject' composition of intangible assets still remains open.

Moreover, despite the high importance and relevance of this topic, as well as a significant amount of statistical data in the studies of leading foreign and Russian scientists, the aspects of the impact intangible assets have on increased competitiveness of TNCs and on increased market capitalization, revenue and asset value are not fully systematized. E.A. Shutaeva *et al.* and P.V. Pavlov *et al.* consider only the issues of service companies functioning in the modern conditions of digitalization [2,3]. I.T. Rustamova, T.P. Danko and A.S. Vyazovikova pay more attention to aspects of managing intangible assets of service companies [4,5].

In this regard, the present research aimed at a systematic analysis of the impact intangible assets have on increased competitiveness of TNCs and the increase in their market capitalization, revenue and asset value. The objectives are: identifying trends that lead to increased share of intangible assets in the value of companies; analyzing the presence of TNCs in the service sector in the ratings for assessing the level of revenue and market capitalization; comparing indicators related to intangible assets with the human development index and the business environment formed in the country; identifying promising sectors for the use of intangible assets in TNCs.

2 Methodology

Thus, to achieve the goal of the study and solve the identified problems, the research used works of leading scientists in the field of intangible assets and the behavior of companies in a transforming economy as basis. Thematic statistical and analytical collections from leading rating agencies and expert communities (including statistical collections of AON Empower Results, GIFT, World Investment Report, and Fortune Global 500 [1,6-9]), as well as information on the activities of multinational companies from open sources were selected as practical data.

An extensive instrumental and methodological apparatus was used: system analysis, synthesis and analogy, classification, quantitative and qualitative analysis, and graphical interpretation of data.

3 Results

The existing global trends indicate that TNCs engaged in the service sector acquire greater weight in the global economy, since they can take fullest advantage of competitiveness due to intangible assets in their structure.

Currently, there are more than 82,000 TNCs that create a network of 810,000 branches worldwide [2]. Comparison with similar data of 1991 reveals the number of TNCs over the past 30 years increased almost 2.5 times, and of their branches 5.5 times [8]. At the same time, the core of the world economy is formed by 500 companies that (according to the Fortune Global 500 rating [9]) received more than 33 trillion USD of income, more than 2 trillion USD of profit and provided about 70 million jobs in 32 countries for 2020 [9]. The largest number of companies during this period is traditionally noted in America, China and European countries. A retrospective analysis by years of implementation of the Fortune Global 500 rating shows that this geographical trend was not always observed. In 1995, the top 5 leaders were Japan (148 companies), the USA (148 companies), Germany (42 companies), Great Britain (35 companies) and France (37 companies). In 2005, the leaders were as follows: the USA (176 companies), Japan (81 companies), France (39 companies), Great Britain (37 companies) and Germany (37 companies). In 2015, Chinese companies forced out a large number of recent leaders, and the balance of power was as follows: the USA (128 companies), China (98 companies), Japan (54 companies), France (31 companies), Great Britain (29 companies). Currently, in 2020, the geographical representation is as follows: China (124 companies), the USA (121 companies), Japan (53 companies), France (31 companies), Germany (27 companies).

At the same time, considering the distribution of companies by sectors reveals a trend towards an increase in service companies not only in quantitative but also in qualitative terms (taking leading positions in the ranking) (Table 2).

Notably, according to the World Bank, the contribution of TNCs in the service sector to world GDP exceeds 75%, and the share of TNCs in the service sector in the Fortune Global 500 rating is more than 50%, the largest number of which is noted in the banking sector [9]. At the same time, during the period under review, TNCs emerged in the service sector related to new industries:

- 2005 (leaders): Healthcare – McKesson Corporation (26th place, revenue 80,514.6 mil. USD); Entertainment – Time Warner (100th, revenue 42,869 mil. USD); Security – leader company Morgan Stanley (107th place, revenue 39,549 mil. USD); Hotels, Casinos and Restaurants – Hilton Group (260th place, revenue 21,792.5 mil. USD); Employment Assistance – Adecco (265th place, revenue 21,441.2 mil. USD); Construction – Centex Corporation (481st place, revenue 12,859.7 mil. USD).
- 2015 (leaders): Internet services and retail trade – Amazon (88th place, revenue 280 511 mil. USD); Real Estate – Greenland Holding group (250th place, revenue 42,515 mil. USD); Apparel – Christian Dior (261st, revenue 60,071 mil. USD); Packaging – International Paper (450th, revenue 26,221 mil. USD); Travel services – TUI (469th place, revenue 142 mil. USD).

- 2020 (leaders): Diversified outsourcing services – Randstand (479th place, revenue 26,500 mil. USD).

Table 2 Distribution of companies from the Fortune Global 500 by industry [9]

Companies involved in the industry	Number of companies			
	1995	2005	2015	2020
Aerospace	9	11	11	13
Airlines	9	7	7	6
Drinks	6	4	3	4
Building materials, glass	3	4	3	5
Chemicals	17	9	8	8
Banking	60	55	55	50
Computers, office equipment	8	13	10	12
Diversified financial institutions	7	4	5	10
Electronics, electrical equipment	31	29	32	26
Engineering structure	14	10	13	16
Product area	35	9	12	11
Food services	1	3	3	2
Pharmaceutical companies	22	21	20	19
Forest and paper products	5	4	-	-
General sales	15	11	7	3
Industrial agricultural equipment	10	7	8	11
Delivery of mail, parcels and cargo	7	9	7	7
Metal products and metals	20	12	16	18
Mining industry, oil products	2	5	25	23
Vehicles and spare parts	25	31	33	34
Network and other communication equipment	-	5	5	3
Oil refining and pipelines	28	31	42	42
Medical products and equipment	10	13	10	15
Publishing, printing	4	2	-	-
Railways	8	4	4	3
Rubber and plastic products	3	-	-	-
Semiconductors and other electronic components	-	5	4	2
Scientific, photographic and control equipment	5	2	-	1
Transportation	2	1	2	3
Cosmetics	3	-	-	-
Specialized retailers	7	12	13	10
Telecommunications	20	23	18	16
Textile	-	-	1	2
Tobacco	4	3	1	2
Trade	21	10	12	19
Public utilities	16	23	25	15
Wholesale	8	11	12	11
Other	62	84	80	92
Total service sector enterprises (out of 500 companies)	269	285	275	314

Source: compiled by the authors according to Fortune Global 500 [9]

All of this contributed to a paradigm shift in the top TNCs in the Fortune Global 500 and the industries they represent. In 2000, the leader of this rating was General Motors Corporation with the revenue of 176,558 mil. USD; in 2020, Walmart (the scope of which is trade) took the first place with the revenue of 523,694 mil. USD (Figure 1) [3].

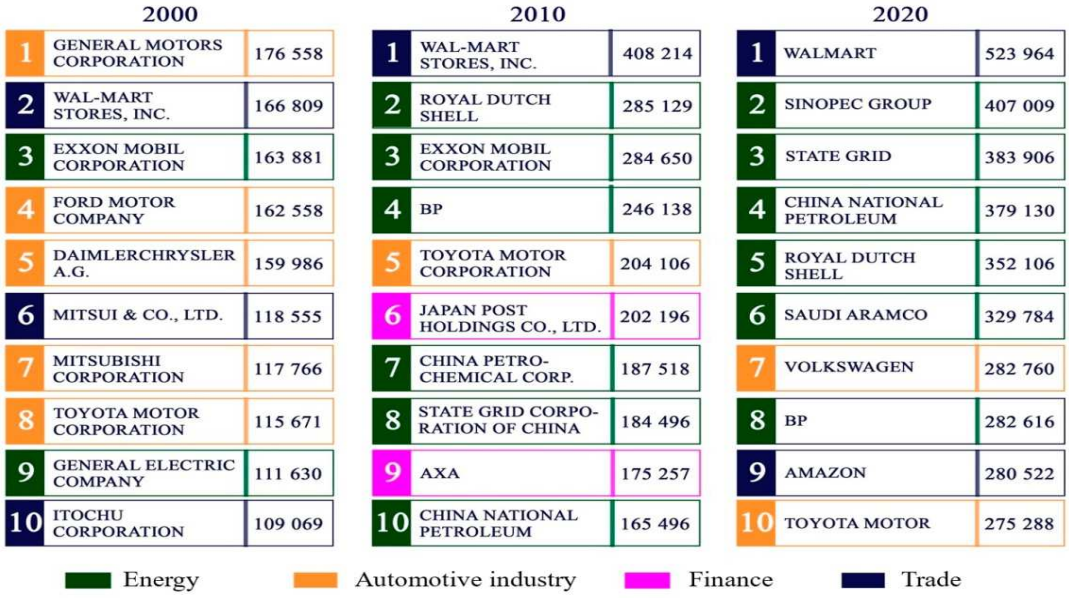

Figure 1 Retrospective analysis of the top TNCs in the Fortune Global 500 [9] by revenue (mil. USD)
Source: compiled by the authors according to Fortune Global 500 [9]

Notably, in 2020, almost all TNCs in the energy industry (Figure 2) lost in revenue compared to 2019, while TNCs in trade, automotive industry and finance, on the contrary, grew. Thus, it will be of interest consider the change in the value of TNCs (value of assets) and their profits depending on the sector of the economy (Table 3).

Table 3 Analysis of the representation of TNCs in the Fortune Global 500 by sectors of the economy [9]

Sector	2015			2020		
	Quantity	Profit, mil. USD	Asset value, mil. USD	Quantity	Profit, mil. USD	Asset value, mil. USD
Space and defense	11	27 241	705 738,9	13	27 256,6	1 018 844,7
Apparel	3	5 776,4	125 719,7	3	9 529,1	152 243
Business services	-	-	-	3	2 908	39 665,5
Chemical products	8	29 546,2	484 802,5	7	12 474,3	457 374,7
Energy	107	228 114,9	10 507 095,9	82	285 098,5	10 704 644,6
Design and construction	13	16 930,1	874 817	13	21 440,9	1 396 339,8
Finance	111	612 650	93 331 579,9	121	784 342,2	102 475 696,8
Grocery store	20	12 803,4	710 677,5	19	17 950	784 678,3
Food, drinks and tobacco	16	65 031,4	878 511,7	17	66 748,6	1 166 351,9
Healthcare	23	104 123,5	1 443 598,3	29	148 662,7	2 772 963,1
Hotels, restaurants and leisure	4	7 845,2	96 582,8	1	3 599,2	19 219,6
Household goods	2	18 156,5	183 059	3	14 390	237 005,4
Industry	19	36 798,7	984 469,5	19	48 069,6	1 235 214
Raw materials	20	6 681	1 053 848,1	23	7 567,9	1 294 472,5
Media	4	22 135,1	245 478,2	3	14 498,4	306 705,5
Automotive industry	34	118 900,9	3 282 252,7	34	83 942,4	4 054 105,7
Trade	15	43 640,5	854 762,8	16	80 217,8	1 203 917,1
Technology	32	184 571,6	2 122 916	35	292 312,7	3 389 142,2
Telecommunications	18	85 778,7	2 394 209,7	15	81 138,6	3 154 630,2
Shipping	20	28 425,2	2 320 734,9	19	25 209,2	3 093 794,2
Wholesale	19	14 461,6	766 096,3	24	21 865,2	1 054 336,2
Total	500	1 669 616,9	123 367 951,4	500	2 049 222,6	140 011 345
TNCs in the service sector and share of the total	275 55%	1 140 367,7 68.3%	104 595 415,1 84.8%	314 62.8%	1 496 623,8 73.03%	118 683 997,1 84.7%

Source: compiled by the authors according to Fortune Global 500 [9]

Table 3 shows that the largest value of companies both in 2015 and 2020 was noted in the financial sector, and in general, the value of all TNCs in the service sector is almost 85% of the value of all TNCs included in the Fortune Global 500 rating [9]. At the same time, singling out companies with the highest asset value reveals that the first 50 will be companies exclusively in the financial sector (the maximum volume of Industrial & Commercial Bank of China is 4,322.5 bil. USD, 7 times more than that of China National Petroleum, the largest TNC in terms of asset value in the energy sector with 608.1 bil. USD).

Intangible assets in any TNC are important both in assessing the value of the company and in highlighting its strong competitive sides (for instance, business reputation). At the same time, according to Brand Finance experts, the share of intangible assets is the highest in TNCs in the service sector. In 2020, TNCs in cosmetics, Internet and software, health, drinks and Media are more than 70% (taking into account the value of disclosed and undisclosed intangible assets and goodwill), and 7 of the 10 most intangible sectors are represented precisely by industries from the service sector (Figure 2).

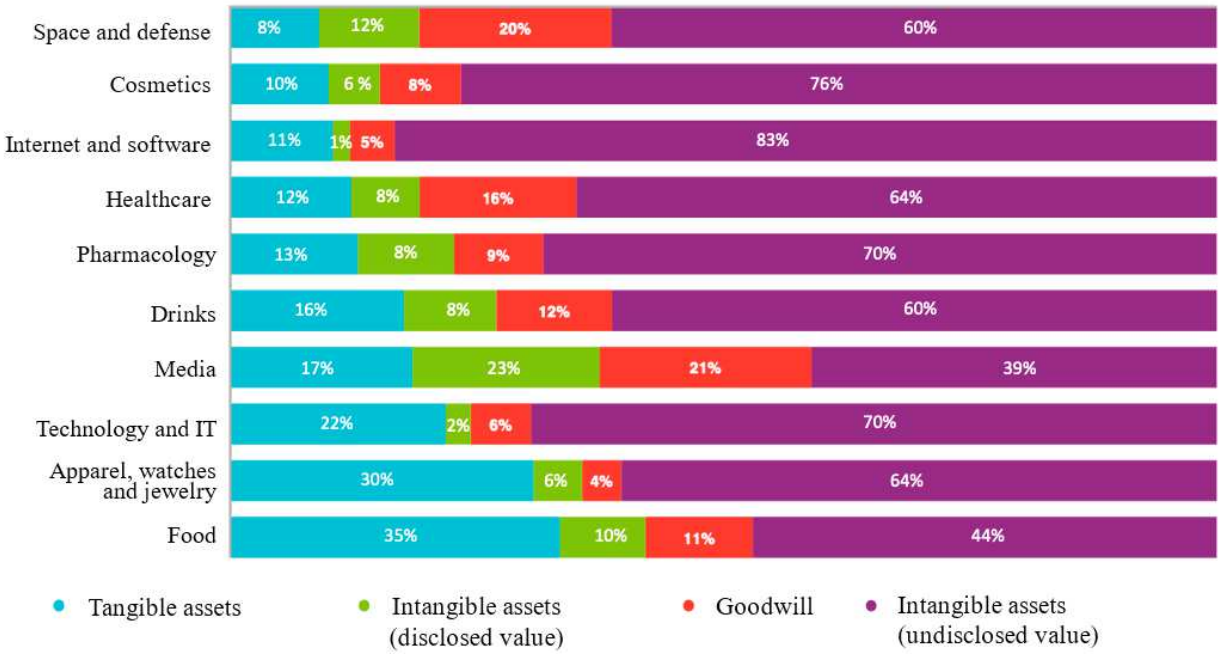

Figure 2 Sectors of the economy with the largest share of intangible assets in their structure, 2020
Source: compiled by the authors according to GIFT *[6]*

The remaining service sectors for the period under review in terms of the share of intangible assets in the structure of their value have the following values: commercial services – 64%, retail trade – 62%, telecommunication services – 60%, household goods – 60%, leisure, tourism, gambling – 55%, logistics – 42%, utilities – 30%, air transportation – 23%, insurance – 17%, real estate – 14%, banking sector – 10%. Comparing similar values over the past 20 years reveals that the largest increase in the volume of intangible assets is observed in the TNCs of the banking sector (6.7 trillion USD).

The largest TNCs in terms of intangible assets in 2020 were Apple (2,151 bil. USD), Amazon (1,694 bil. USD), Saudi Aramco (1,651 bil. USD), Microsoft (1,598 bil. USD) and Alphabet (838 bil. USD). In turn, the overall rating of the 100 largest TNCs in terms of intangible assets in 2020 included 18 TNCs from the Internet and software sector; 14 TNCs each from the pharmacology and technology and IT sectors; 7 TNCs from the retail trade sector; 6 TNCs each from the telecommunications and healthcare sectors; 5 TNCs from the beverages sector; 4 TNCs from the banking services sector; 3 TNCs each from the media, cosmetics, space and defense, and food sectors; 2 TNCs each from the oil and gas, design and construction, Apparel, watches and jewelry, and logistics sectors; 1 TNC each from the automotive industry, commercial services, insurance, chemical products, real estate, and utilities sectors. In 2020, there was rapid growth in this rating not only for TNCs in the service sector but also for those engaged in production processes, for example, Saudi Aramco, a TNC from the oil and gas sector; Tesla from the automotive industry sector; Bristof Myers Squibb from the pharmacology sector; Reytheon Technology the space and defense sector; and Wuliangue from the beverages sector.

Despite the understanding of the importance of intangible assets in the value of TNCs, there are still great difficulties in their accounting, cost calculation and disclosure of full information. Moreover, companies themselves often do not fully understand how exactly the presence of intangible assets (for example, a recognizable

brand, relationships with customers and suppliers, the company's human resources) affect the company's value. The studies of intangible assets presented by Brand Finance experts, conducted on more than 58.8 thousand companies from 120 countries, indicate that about 15% of the value of companies is closed intangible assets and closed goodwill, and in a number of industries this value approaches a quarter of the company's value (for example, the media sector, see (Figure 2).

Often the influence in disclosing all information about intangible assets is at the level of the country as a whole. Thus, the following countries with the largest share of intangible assets in the value of companies in 2020 can be singled out: the USA (75%), Denmark (73%), Ireland (73%), Saudi Arabia (71%), Finland (62%), Sweden (60%), Switzerland (59%), France (57%), Morocco (56%), and Argentina (56%). In these countries, as well as in a number of other European countries (including Belgium, Italy, Portugal, and Germany), there are companies with the largest value share of disclosed intangible assets.

At the same time, a number of the above countries also have the best financial performance, the best values of the human capital index (for example, Finland – 2nd place, Switzerland – 3rd place, the USA – 4th place, Denmark – 5th place, Germany – 6th place, and Sweden – 8th place) and the greatest prospects for doing business, including data on the speed of registering property and the speed of starting a business (New Zealand – 1st place, Denmark – 4th place, the USA – 6th place, and Sweden – 10th place) [10,11].

A key feature of intangible assets is the fact that due to support and development mechanisms, they do not lose but multiply their value and can create a multiplier effect during operation. This significantly increases the competitive advantages of TNCs, especially in times of crisis (for example, the well-known problems that befell companies in the service sector in connection with COVID-19. At the same time, they were able to restore their former positions in the best possible way and even increase the volume of value, profit and revenue).

TNCs in the service sector can be divided into three main types [4]:

- TNCs in the consumer services sector, including TNCs of individual services (retail sales, trade, food services, utilities), and TNCs of public services (health, education, media and entertainment, consulting), developing at the expense of human capital, goodwill and general company reputation;
- TNCs in the infrastructure services sector, including TNCs of physical infrastructure (airlines, railways, transportation, wholesales), TNCs of information infrastructure (banking, diversified financial institutions, telecommunications), developing through innovation and cost reduction;
- TNCs in the KIBS (Knowledge Intensive Business Services) sector, including TNCs in the engineering and scientific sector (IT companies, scientific and educational organizations, engineering, pharmaceutical companies), developing through the active introduction of new innovations and economies of scale.

At the same time, accounting for intangible assets at the global level is carried out based on the International Financial Reporting Standard IFRS 3, on the basis of which intangible assets are divided into 5 main categories: related to marketing, related to customers, received on a contract basis, having a technological base, related to works of art. In turn, a number of foreign experts use their specified categories of intangible assets (Table 4).

Thus, in addition to the traditional categories that are part of the company's intangible assets, including sources of intellectual property, the presence of property rights and business reputation, it is possible to include the human capital available in the company (knowledge, skills, connections of the company's employees), due to which formation of all other tangible and intangible assets of the company often occurs.

In connection with the presented division of TNCs according to the IFRS 3 classification, as well as the classification of intangible assets based on the International Financial Reporting Standard IFRS 3, it is possible to single out those intangible assets that have a greater impact on the value of companies. For TNCs of the first type, the most 'valuable' will be intangible assets associated with marketing, for TNCs of the second type, intangible assets based on customer relationships, and for TNCs of the third type, intangible assets based on technology and documented. Yet for all TNCs in the service sector, regardless of their belonging to any of the above sectors, human resources will be of great importance in the formation of final financial indicators, allowing the formation of all these types of intangible assets to one degree or another.

An important aspect of the growth of efficiency and profits of TNCs in the service sector, which is particularly affected by intangible assets, is logistics. This is justified by the fact that the logistics of the service sector has a number of features that distinguish it from traditional logistics. So, among the main features of the logistics of TNCs in the service sector, the following should be highlighted [12]:

- planning and regulation of working time, but not of transportation;
- storage of information and accumulation of knowledge (staff training), rather than storage of raw materials, materials and goods;
- information processing, not stock management;
- collection of information, not delivery of materials;
- planning and organizing the work of personnel, not production processes;
- control of the communication cycle, not the distribution and delivery of products.

Table 4 Classification of intangible assets

Report on Comparison of the Impact of Financial Statements of Intangible Assets (Ponemon Institute LLC Report, AON Empower Report)	**Intellectual property**
	Patents, copyrights, trademarks, trade secrets, know-how
	Rights that may be protected by intellectual property
	Marketing rights, usage rights, franchise agreements, royalty agreements, licensing agreements, mortgage service rights
	Brand that can be protected by intellectual property
	Brand value, its degree of inclusion in social networks
	'Hard' intangible assets that may be protected by Intellectual Property
	Goodwill, software licenses, internet domains
	Data that may be protected by Intellectual Property
	Information stored: program code, data (others), databases, customer lists, video/audiovisual materials, confidential information
	Non-income rights
	Intangible assets that generally do not affect income generation: non-competitiveness agreements, suspension agreements
	Connections and relationships
	Relationships with customers, relationships with suppliers
	Public rights
	Drilling rights, import quotas, planning/zoning permit, water rights, wireless spectrum rights, carbon exhausts rights
Categories of intangible assets according to IFRS 3 (Brand Finance GIFT report)	**Marketing related intangible assets**
	Trademarks and names; service marks and collective marks, certification marks; trade uniform (unique color, shape or package design); newspapers; internet domain names; headings; agreements on non-competition
	Intangible assets based on customer relationships
	Client lists; order or production of unfulfilled orders; customer contracts and related customer relationships; non-contractual relationships with clients
	Intangible assets secured by documents
	Agreements on licensing, royalties, moratoriums; contracts for advertising, construction, management, maintenance or supply; lease agreements; building permit; permissions; franchising agreements; operation and broadcasting rights; usage rights such as drilling, water, air, minerals, logging and route management; service contracts; employment contracts
	Technology based intangible assets
	Patented technology; computer software; database; trade secrets such as secret formulas, processes, recipes
	Intangible assets associated with works of art
	Plays, operas and ballets; books and magazines, newspapers and other literary works; Musical works such as compositions, lyrics and commercials; maps and photos; video/audiovisual materials, including films, music, videos

Source: compiled by the authors according to AON Empower Results and GIFT [1,7]

Thus, it can be noted that for TNCs in the service sector, logistics costs not only have a fundamental impact on the company's productivity, but also make up a large share of the costs, since they include almost the entire cycle of "production" of services [13]. Thus, one of the options for reducing logistics costs is the use of logistics platforms, i.e. special business models developed to improve the efficiency of all logistics operations of supply chains [13]. And another option is to use the methodology of the intellectual capital management process (ICMP), which allows you to build management and logistics processes for all intangible assets, both in the internal environment of companies and in the external one [14].

This is due to the fact that the purpose of the logistics operations of TNCs in the service sector is to ensure the supply and production for the end consumer of the necessary basic and related services at the set time and place, in the requested volume and at the set price (taking into account cost reduction for the service TNC itself). In this regard, one of the basic principles of logistics at TNCs in the service sector is the organization of a continuous process of providing all departments with the necessary

resources (information, labor, temporary and administrative), primarily those that are intangible assets for companies.

At the same time, approaches in logistics, as in all other areas of TNC activity, also need to be revised due to the need to comply with the concept of sustainable development and the global imbalance in the world economy caused by the COVID-19 pandemic, as well as the growing role of digital technologies and the widespread development of the industry. 4.0, which contributes to the complete transformation of business models for the functioning of companies. These trends are also confirmed by AL-ABABNEH H.A., who, in the course of his research, identifies the main trends in the development of the logistics industry in the world, taking into account new trends in the development of the world economy [15].

Scientists-economists T.P. Danko and A.S. Vyazovikova in their study confirmed the hypothesis that the revenue of companies depends on the value of its intangible assets. Apple was chosen for the assessment, which has the highest value of intangible assets and is in the top 3 in terms of revenue of the world's leading TNCs. Calculating the correlation coefficient revealed that the market value of the company is highly dependent on the value of intangible assets (R=0.760), but an even greater dependence was observed between the amount of revenue and the value of intangible assets (R=0.816) [5]. According to the value of disclosed intangible assets, the company pays great attention to interaction with consumers and maintaining their loyalty to the brand (40% of the value of all intangible assets), marketing components of intangible assets (23% of the value of all intangible assets), and then the development of technologies, know-how and patents (21%).

Financial TNCs have a different strategy; they are represented by the only company from Russia which was among the world's leading companies in 2021 [9] – Sberbank PJSC. The company built its work on intangible asset management by creating a diversified ecosystem that includes various services which allow customers to receive services in the field of finance, entertainment, food, real estate, healthcare, transport, consulting, and education. This position allowed Sberbank to increase its net assets almost 3 times during the formation of the ecosystem, becoming the largest bank in Russia and the strongest banking brand in the world with a Brand Strength Index (BSI) rating of 92.0 out of 100 and an elite AAA+ rating. Despite this, PJSC Sberbank is actively involved in the development of the company's human potential and supports the corporate university which forms a knowledge bank and trains tens of thousands of company employees in more than 300 educational programs to develop flexible skills and professional competencies.

The trend of creating corporate universities among the leading TNCs, as well as their interaction with scientific and educational structures, is quite strong. According to Deloitte, the cost of corporate training in the world is about 150 bil. USD annually, and collaborations between scientific clusters, universities and TNCs allow achieving a synergistic effect for all participants. For example, the Shenzhen-Hong Kong cluster, which is in the top 3 clusters represented in patent and scientific activities, according to the Global Innovation Index, and which united the University of Hong Kong and the company Huawei, allowed to significantly increasing the volume and quality of innovations companies and the share of market sales.

Indicators of monitoring, management and development of intangible assets are taken into account when implementing the development strategy of companies; this is a feature of intangible assets management by leading TNCs in the service sector. At the same time, intangible assets management is based on a number of general principles, for example:

- incorporating the intangible asset management strategy into the overall development strategy of TNCs;
- using tools for assessing the value of intangible assets;
- consistency, complexity and synergy in the formation, management and development of intangible assets;
- building up the innovative potential of TNCs based on the company development strategy, including building its business reputation;
- intangible assets management should increase the company's competitive advantages.

4 Conclusion

Thus, we can conclude that at present, TNCs engaged in the service sector are becoming increasingly important in the global economy, which can be conditionally divided into TNCs in the consumer services sector, TNCs in the infrastructure services sector and TNCs in the intellectual services sector. In many respects, this trend is due to the fact that it is TNCs in the service sector that can fully use the advantages of intangible assets that have received the greatest impact due to globalization, the development of digitalization (Industry 4.0), and also taking into account other trends in the world economy. This is also confirmed by the fact that the World Bank estimates that the contribution of TNCs in the service sector to world GDP exceeds 75%, and the share of TNCs in the service sector in the Fortune Global 500 rating is more than 50%, of which the largest number is represented by TNCs in the financial sector.

At the same time, there are still certain difficulties in accounting for intangible assets in the value of TNCs. This situation is sometimes associated with the policies of countries in general, and their investment potential, as well as shortcomings in the application of financial reporting standards (IFRS 3) for specific industries and types of intangible assets.

Undoubtedly, at present, intangible assets make up a significant share in the value of modern multinational companies, especially those in the service sector. At the same time, the issue of competent accounting remains

important, which allowed increasing the disclosure of intangible assets by companies, as well as developing strategies to increase the volume of intangible assets and competently manage them. Of help here are digital technologies and collaborations with scientific and educational organizations, which will allow (through a synergistic effect):

- attracting new talents and building up the necessary skills and competencies for the company;
- implementing new approaches to innovation and integrating new technologies into existing workflows;
- studying market changes and hedge risks to identify new products and services, as well as the most competitive market segments;
- including integrated change management programs, flexible organizational structures and flexible working methods in their activities.

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THE ROLE OF OPENNESS TO CHANGE IN AUTOMATED PARCEL LOCKER USAGE INTENTION AMONG ONLINE BUYERS IN MALAYSIA

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Keywords: automated parcel locker, time constraint, supplier image, openness to change, intention to use.
Abstract: Automated parcel locker is a self-service technology to facilitate parcel collection and has been introduced in Malaysia in 2016. Although automated parcel lockers have advantages over home delivery, customers still prefer the traditional method. Subsequently, this study aims to explore the role of time constraint, supplier image, and openness to change toward online buyers' intention to use automated parcel lockers. Based on the stimulus-organism-response theory, the study conducted both an online survey and an on-site survey. Two hundred and sixty-five respondents' data were used for data analysis, and the results indicate that time constraint has a negative influence on openness to change, and supplier image has a positive influence on openness to change. Openness to change was found to mediate the relationship between time constraint and intention to use and between supplier image and intention to use. Automated parcel lockers providers will benefit from the outcomes of this study.

1 Introduction

Increasing consumer demand for online shopping has a vital impact on the last-mile delivery services. Logistics providers need to be more creative to ensure the online buyers' satisfaction which supporting the repurchase intention from the same platform, thus the platform will reuse the same logistics provider to deliver their products [1]. Thus, technological factors always a main source of innovation to meet the customer's expectation.

Self-service technology (SST) is a technological interface that enables customers to produce and consume services without requiring direct assistance from company employees [2]. In last-mile delivery, SST is provided in the form of a parcel locker, which is frequently used for self-service collection and return of online purchases [3] It was reported that SST facilities would continue to evolve and play a more prominent role in service delivery [4]. In addition, SST has been introduced in the delivery process as a cost-effective approach to reducing waiting time [5].

Waiting time is a crucial factor in making online customers happy and satisfied. Online purchases are becoming more associated with expectation of short delivery time such as next day delivery or same day delivery [6]. Due to excessive transit times, about 43 per cent of consumers in Malaysia are discontented with their parcel delivery experience [7]. Compared to the regional average delivery time of 3.3 days, buyers in Malaysia need to wait for 5.8 days before their parcel arrives. Furthermore, late delivery and lack of communication about delivery status account for over 90 per cent of customer complaints and negative comments. According to [8], logistics companies always concerned with obstacle to prompt delivery which is traffic congestion. Therefore, an automated parcel locker services has been introduced as an innovative solution to reduce waiting time and provide efficient last-mile delivery.

During the last few years, logistic service providers in Malaysia also managed to provide an innovative solution to parcel deliveries by providing automated parcel lockers as well as designated pick-up points. Many logistics businesses in Malaysia provide parcel delivery services, with Pos Laju, the national courier service founded in 1988, being the largest. The use of an automated parcel locker system in Malaysia, called Pos Laju Ezibox, began in 2016 to assist parcel deliveries. According to the yearly report of postal and courier service published by the Malaysian Communication and Multimedia Commission in 2018, the number of automated parcel lockers in the first half of 2018 was recorded at 110. The numbers rose from 58 automated parcel lockers recorded in the first half of 2017—equivalent to a 53% increase—which means the top 10 courier companies in Malaysia started to provide more automated parcel lockers to their customers [9]. In this notion, the increase of automated parcel lockers means that the logistics service providers intend to reduce the time waiting for home deliveries.

Home deliveries is expanding and developing rapidly [10] and remain the more popular choice amongst customers in the last-mile delivery context [11]. According to [12], in Singapore, 80 percent of respondents prefer home delivery to self-collection options. Similarly, the condition in Malaysia also indicated that customers prefer home delivery; numerous complaints were directed at the Communications and Multimedia Minister, mainly regarding home deliveries [7]. Last-mile logistic companies created automatic parcel locker services as an

innovation to improve online purchasers' experiences. These services offer advantages over home deliveries, such as minimising inefficiencies associated with consumers waiting at home for their delivery [13]. However, it seems that online buyers are still favouring home delivery. To assure the success of automated parcel locker services, the study attempts to uncover the elements impacting online purchasers' intention to use automated parcel lockers in Malaysia. Furthermore, despite being considered a new innovation, automated parcel locker services have been largely overlooked by researchers in the last-mile delivery.

To analyse online customers' intention, the current study uses the stimulus organism response (SOR) paradigm and provide insight regarding their openness to switch to another collection mode to address practical issues and fill the research gaps. Many studies in parcel service delivery which looking for intention to use, discover influencing factors such as time pressure, relative advantage, convenience, personal innovativeness, security and attitude [11], [14-16]. However, there are hardly any studies testing time constraints, supplier image, and openness to change in a single study. Hence, the current study creates a new link between time constraint and openness to change and between supplier image and openness to change. Supplier image and time constraints are incorporated in the current study because these variables can explain customer behaviour [17,18]. Similarly, as individuals with high levels of openness to change are more open to trying new things, the current study suggested that it will influence their intention to use automated parcel lockers. Besides, current study contributes by providing the perception in perspective of Malaysian customers, hence will provide a better understanding on the establishment of the parcel locker services in the country.

Multiple companies offer automated parcel locker services in Malaysia, such as Pos Laju, Ninja Van, and Parcel365; each company has a different image from customers' perspectives. This could be influenced by their past experiences of making business transactions or being influenced by advertisements. Hence, supplier image is crucial in influencing customer openness to change and intention to use automated parcel lockers because companies with a good image could provide better services compared to companies with an unsatisfactory image. Additionally, customers are needed to travel to the automated parcel locker location to retrieve the parcel. Customers expect the parcel collection to consume less time and effort. Therefore, time constraints could further explain the online buyers' behaviour. The customers who are having time constraint issues could have difficulty using automated parcel lockers. Based on the explanation above, supplier image and time constraint were chosen to develop the SOR framework.

The current study aims to investigate the factors that influence online buyers' intention to use parcel lockers by operationalising time constraint and supplier image as 'stimulus,' openness to change as 'organism,' and intention to use as 'response', all based on [19] SOR model. As customer behaviour can influence the strategic decision of the parcel delivery company [20], the implication of this study may serve as a reference for these companies, especially in Malaysia, to improve their services in order to attract new customers. In addition, understanding the customer behaviour is important factor to survive in the current market [21]. Besides, findings from this study also enrich literature in automated parcel locker and self-service technology contexts, and also provide timely information for the last-mile delivery provide to craft a better marketing plan to ensure this new technological approach will be used and sustainable.

2 Literature review

2.1 Stimulus–Organism–Response theory

Mehrabian and Russell presented the SOR theory for the first time in 1974. This theory states that environmental stimuli (S) can stimulate a cognitive and affective reaction (O), which generate a behavioural response (R) [19]. Stimuli are external elements of the physical environment, according to [22], whereas an organism is an individual's internal processes and structures that occur between stimuli and responses. Various factors of the external environment to which people are exposed, such as product conditions, design, shopping ambiance, and product attributes, operate as stimuli that influence change in an individual's experiences, according to this model [23]. Additionally, [24] stated that the organism will take an internal or external behavioural response to external stimuli after a sequence of cognitive activity. The internal response will be manifested as an individual attitude, while the external response will be manifested as specific behaviour [25].

The SOR model has been applied in a variety of settings such as in social commerce [26], brand loyalty [27], and self-service technology [28,29]. Considering that past studies regarding self-service technology have applied the SOR model, the present study looks to strengthen the literature by incorporating time constraint, supplier image, openness to change, and intention to use in a single research model. The research framework is shown in Figure 1.

The present study suggested that time constraint and supplier image could be the factors representing the stimuli since both of the factors originated from the online buyers' surrounding environment. The stimulus is likely to influence the online buyers' internal response and openness to change. Moreover, online buyers with a high level of openness to change are likely to use the automated parcel locker.

2.2 Intention to use

Intention was defined by [30] as the amount of effort someone is willing to exert to perform a behaviour. It was further explained by [31] that intention has the meaning of

a person's readiness to perform a certain behaviour. Generally, the stronger a person's intention to do a behaviour, the stronger the actual behaviour will be carried out. The intention in this research context is online buyers' intention to use the automated parcel locker for parcel collection.

Past researches have shown that intention has been used in many contexts to determine consumer behaviour, for instance, in parcel station usage intention [32], self-collection services [11,33], self-service technologies in air travel [34], reverse logistics [35], insurance planning [36], airline services [37] and augmented reality (AR) application [38]. Hence, the current study looks for factors influencing online buyers' intention to use automated parcel lockers in the Malaysian context.

2.3 Time constraint

According to [39], an assessment of limited time available for processing information and making decisions is referred to as a time constraint or time pressure. [40] stressed that time pressure usually increased the desire to lock into one problem-solving strategy and decreased the openness to other choices. In this notion, when pressured with a time constraint, an individual's level of openness to change will be reduced and may proceed with the method he knows best. The time constraint in this study is the online buyers' perception of the restricted time available for parcel collection.

[41] suggested that negative time pressure will decrease affective and emotional connection between retailer and supplier. [42] explained that the time constraint of a self-service technology transaction negatively influences customer's attitude toward the technology. Additionally, [17] emphasised that time pressure was the strongest determinant of lower hand hygiene behaviour among veterinary referral practices in the United Kingdom. Based on the literature, it was confirmed that time constraint was able to influence behaviour negatively.

With regards to the human lifestyle in general, some would love to travel while some are happy being at home. Similar to online buyers' lifestyles, some would love to travel for self-collection, and some would prefer home delivery. As travelling toward automated parcel locker locations will consume time, online buyers with time constraints could face difficulty performing self-collection. Suppose the online buyer perceived himself as always being constrained by time. In that case, he is likely to have difficulty travelling to parcel locker locations and is expected to have a weaker level of openness to change toward using automated parcel lockers. Hence, the current study theorises that time constraints will have a negative influence on openness to change. Therefore, the first hypothesis is:

H1: Time constraint has a negative relationship with openness to change.

2.4 Supplier image

[43] defined image as "the set of meanings through which an item is recognised and humans describe, recall, and react to it". The perception of a brand as represented by brand associations in customer memory was termed as supplier image [44]. According to [45], store image refers to a customer's view of a store based on its multi-attributes. The image was identified as an important factor in the evaluation of the services and company [46]. The supplier image in this study refers to how online shoppers perceive automated parcel locker service providers.

Literature provides positive association between image and customers'' attitudes [18,47]. Hence, it was confirmed that image could affect behavioural response. For parcel delivery, considering that the traditional delivery method has some issues and that there is an alternative solution, the online buyer needs to decide which method works best. Each of the companies offering parcel delivery services holds a different level of the image in customers' memory. This could be influenced by several factors such as customers' past experiences or being influenced by excellent advertisement. Therefore, maintaining a positive image is an important task for the providers since it is crucial to influence customer openness to change and intention to use. Companies with a good image hold better evaluations from the customers. Hence, online buyers who perceive that the automated parcel locker provider is having a good image and can offer good services could be tempted to use the automated parcel locker. Therefore, the following hypothesis is proposed:

H2: Supplier image has a positive relationship with openness to change.

2.5 Openness to change

Openness to change was described by [48] as the willingness to promote change and have a positive impact on the change's potential consequences. Originated from Schwartz Value System, openness to change captures the unpredictability of an individual's thoughts and emotions [49]. Later, [50] stressed out that value is a critical motivator of behaviour and attitudes. Generally, change is very close to the notion of improvement, implementation, and reform [51]. According to [52], individuals with openness to change value tend to cherish new occurrences. Openness to change in the current study context is the online buyers' willingness to move from using traditional home delivery to automated parcel lockers for data collection.

Online buyers who have a high level of openness to change and face problems with traditional delivery may be willing to use an alternative such as an automated parcel locker. Switching to an alternative could facilitate their parcel collection. Openness to change is measured using a higher-order construct. The current study uses three dimensions to represent openness to changes, which are self-direction, stimulation, and hedonism. [53] explained that the dimension of self-direction and stimulation in

openness to change are related to new product adoption behaviour. Hence, openness to change is an important factor for new product adoption behaviour.

The relationship between openness to change and intention to use was confirmed by past studies. A positive relationship was revealed by [54] regarding cosmetic consumption and [55] regarding entrepreneurial intention. Hence, the hypothesis is:

H3: Openness to change has a positive relationship with intention to use automated parcel locker.

2.6 Mediation

Mediation analysis is essential for model enhancement and theoretical advancement [56]. Therefore, the goal of this study was to improve the model's predictive power by including openness to change as a mediator for the association between time constraint and intention to use, as well as for the relationship between supplier image and intention to use.

Time constraint is argued to have a negative influence on openness to change. In addition, self-service parcel collection can make the delivery of products timely. However, influencing factors such as travel time to automated parcel locker locations may impair customers' decisions. Besides, time constraint to complete a self-service transaction was found to negatively influence customer behaviour [42]. Literature also provides evidence of openness to change to influence intention to use. Therefore, the author's study theorises that openness to change mediates the relationship between time constraint and intention to use automated parcel lockers. Hence, the hypothesis for mediation is:

H4: Openness to change mediates the relationship between time constraint and intention to use.

Considering that customers' image is an important factor in evaluating a service, image positively affects customers' intention [57]. The authors argued that supplier image positively affects customers' openness to change. Additionally, the image was reported to positively influence intention to use [58,59]. Considering that image is suggested to have a positive effect on openness to change and consistently has a positive effect on intention, and considering that openness to change was proved by literature to have a positive association with intention to use, the current study suggests that:

H5: Openness to change mediates the relationship between supplier image and intention to use.

Figure 1 demonstrates the research framework of the study.

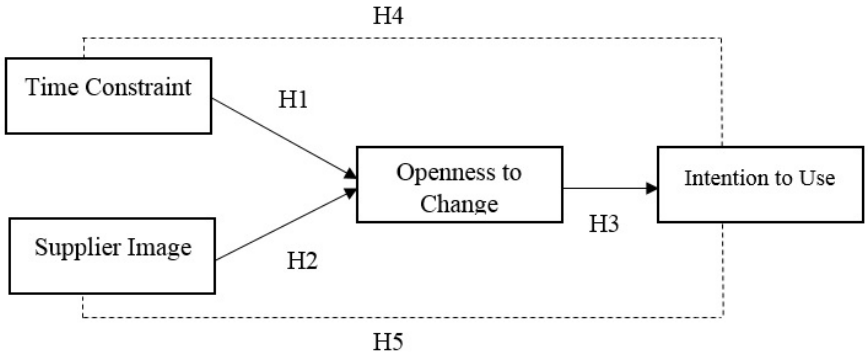

Figure 1 The research model [authors, n/a]

3 Methodology

To accomplish the research goal, this study utilised a quantitative method to answer the proposed hypotheses. A self-administered survey questionnaire was most appropriate for the research purpose because the unit of analysis was at the individual level. In addition, due to the lack of a complete sampling frame, a purposive sampling strategy was used. There were two sections to the questionnaire. The first half of the survey asked about respondents' demographics, such as their age, gender, educational level, employment, and monthly income, whereas the second section asked about the study's variables.

A pre-test was administered prior to the actual data collection to ensure that the statements were clear and that the measuring items were understood. A face-to-face pre-test with ten respondents was conducted, simulating the situation during real data collecting. During the test, the time needed to answer the questionnaires was recorded, with an average of around five to eight minutes to fully complete the questions.

Data were collected among online buyers who never experienced using an automated parcel locker. The initial plan for data collection is the on-field survey in Selangor and Kuala Lumpur because Kuala Lumpur is the capital representing Malaysia. However, due to the COVID-19 pandemic outbreak, data was gathered using an online survey via Google Forms. The initial location for data collection was changed; hence online buyers across Malaysia participated in this study. The link to the survey was distributed to multiple groups on WhatsApp and Facebook starting August 2020 until early January 2021. To improve data accuracy, a filter question of 'Had experience with an automated parcel locker' was included in the online survey.

In late December 2020, on-site surveys were conducted in major shopping malls to increase the number of responses. Shopworkers were approached when there were no customers inside. Next, the workers were asked if they are online buyers and their experience using an automated locker. Only those who never use automated parcel locker and the active online buyer was selected as sample. Recognising the importance of data quality, it is critical that respondents participate voluntarily in this study. As a result, the respondents were first asked if they wanted to participate.

Respondents who agreed to participate were given the questionnaires. More than 300 online buyers completed the online survey and face-to-face survey. After sorting, only 265 surveys were valid. The sample size should be determined by the power of analysis based on the number of predictors, as suggested by [60,61]. According to [62], a study with two predictors requires at least 66 sample sizes to attain a 80% power with a medium effect size and 5% level of significance. As a result, a sample of 265 respondents was sufficient to test the research model in this study.

All of the items for measuring the constructs were adopted and altered from prior studies because the current study employs Smart Partial Least-Squares (PLS) software version 3.3.3 by [63] which is based on confirmatory factor analysis (CFA). Despite the fact that some of the items have already been used in other studies, the items' content was altered to fit this study context without compromising the original meaning. The items were time constraint [17], supplier image [45], openness to change [64], and intention to use [65]. Items were adapted from these studies due to a smaller number of items compared to other studies. A large number of items will make the respondents lose interest in answering, thus affecting the quality of data. The measurement model and structural model were examined using [63]'s Smart Partial Least-Squares (PLS) version 3.3.3 software.

4 Analysis and findings

265 complete sets of valid questionnaires were received in total. Around 55 % of those polled were between the ages of 18 and 25. 26–33 years old (27.9%), 34–41 years old (9.8%), 42–49 years old (3.4%), and 50 years and older (3.8%) were the other age categories. Females made up the majority of the responders (61.1%). The majority of respondents (64.5%) have a bachelor's degree, followed by 18.5% with a diploma and 9.4% with a high school certificate. Masters (6.8%) and Ph.D. (6.8%) had the lowest percentages among educational categories (0.8%). RM1000–RM2000, RM2001–RM4000, RM4001–RM6000, and more than RM6001 were the four categories of monthly income. The majority of respondents earn between RM2001 and RM4000 (38.5%), followed by RM1000 and RM2000 (31.7%), RM4001 and RM6000 (5.7%), and more than RM6001 (4.9%). Since they are students, a total of 19.2% have no income. Data on employment and educational level were also gathered. 62.3% of respondents were employed by the private sector, while 9.8% were employed by the government. Students made up 11.7% of responses, while unemployed people made up 7.2% and others made up 9.1%.

The current study practised variance-based Structural Equation Modelling (SEM) as proposed by [66] and [67] on account of the study's predictive approach. Before proceeding with the measurement model, a normality test should be performed. The normality test was carried out using Web Power to calculate multivariate skewness and kurtosis. The data was slightly not normal, as revealed by the results of Mardia's multivariate skewness (β = 8.370976, p 0.01) and Mardia's multivariate kurtosis (β = 93.401411, p 0.01), hence the Smart PLS software was appropriate to be used for analysing data [63].

Using a common method variance with data from a single source can lead to major errors [68], [69]. Hence, the current study used both procedural and statistical methods of analysis to solve this issue. The study used a different anchor scale to measure the study's constructs for the procedural technique [68,70]. A 7-point Likert scale was used to assess the intention to use while a 5-point Likert scale was used to assess the other constructs. With single-sourced data for statistical analysis, [71,72] recommended testing full collinearity against the possibility of Common Method Bias. Therefore, all variables are regressed against a common variable. A variance inflation factor (VIF) value of less than or equal to 3.3 shows no bias in single-source data. Table 1 presented that VIF values less than 3.3 were found in the analysis, demonstrating that CMV was not a profound issue.

Table 1 Full collinearity testing

BI	OTC	SI	TC
1.610	1.387	1.693	1.152

4.1 Assessment of the measurement model

To measure the hypothesis comprising of measurement and structural model, current study used a two-step approach. The structural model investigates the relationships between the exogenous and endogenous constructs in the research model, whereas the measurement model investigates the relationships between the items and their constructions; as depicted in Figure 1. Convergent and discriminant validity must be validated during the measurement model stage. To ensure all items accurately measure their respective constructs, the items must attain the convergent validity criterion. If the loading and average variances extracted (AVE) are equal or higher than 0.5, and the composite reliability is more than 0.7, the reflective measurement is valid and reliable [60]. Table 2 shows that all of the criteria for establishing convergent validity have been attained; thus, the result indicates that convergent validity was not an issue in this study.

Table 2 Convergent validity

First Order	Second Order	Item	Loading	CR	AVE
Time Constraint		**TC1**	0.874	0.866	0.685
		TC2	0.897		
		TC3	0.697		
Supplier Image		**SUP1**	0.833	0.930	0.688
		SUP2	0.851		
		SUP3	0.773		
		SUP4	0.844		
		SUP5	0.859		
		SUP6	0.815		
Self-direction		**SD1**	0.787	0.868	0.687
		SD2	0.852		
		SD3	0.845		
Stimulation		**STI1**	0.864	0.893	0.735
		STI2	0.850		
		STI3	0.858		
Hedonism		**HED1**	0.837	0.873	0.632
		HED2	0.728		
		HED3	0.796		
		HED4	0.815		
	Openness to Change	**SD**	0.920	0.926	0.807
		STI	0.896		
		HED	0.878		
Intention to Use		**BI1**	0.948	0.971	0.918
		BI2	0.966		
		BI3	0.961		

The heterotrait–monotrait ratio of correlations (HTMT) was established to determine discriminant validity, as recommended by [73]. Table 3 reveals that all HTMT values were less than 0.85, indicating that discriminant validity issues were not present [74].

Table 3 HTMT

Construct	BI	OTC	SI	TC
BI				
OTC	**0.481**			
SI	**0.597**	**0.479**		
TC	**0.174**	**0.261**	**0.335**	

Note: BI=Intention, OTC=Openness to Change, SI= Supplier Image, TC=Time Constraint

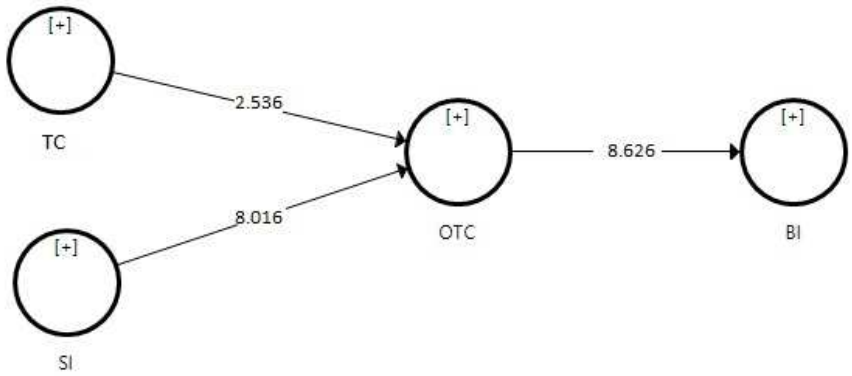

Figure 2 Structural model [authors, n/a]

4.2 Assessment of the structural model

To solve collinearity issues, [60] proposed that the variance inflation factor (VIF) values of all the endogenous constructs in the study model should be examined. The VIF critical value, according to [75] is less than 3.3. The VIF values in this investigation were lower than the threshold value of 3.3, indicating that collinearity is not an issue.

A 5000-sample bootstrapping approach was implemented to examine the hypothesis of the study model as suggested by [60]; the findings are shown in Figure 2. For a hypothesis to be declared supported, the beta value should align with the hypothesis with a T-value of greater than or equal to1.645, a P value of greater than or equal to 0.05, and no zero values in between the lower level (LL) and upper level (UL) for the confidence interval.

Firstly, the effect of time constraint and supplier image was tested on openness to change. The R^2 was 0.207, indicating that both time constraint and supplier image explained 20.7% of the variance in openness to change. R^2 indicates the variance on endogenous constructs explained by exogenous constructs. As a result, with an R^2 of 0.207, the exogenous construct of the study could only explain 20.7% of the overall variance in respondents' openness to change in the current study. Second, the effect of openness to change was tested on intention to use. With R^2 of 0.198, openness to change could only explain 19.8% of the overall variance in intention to use an automated parcel locker.

The result shows that time constraint (β = -0.127, p< 0.006) is negatively related to openness to change, hence H1 is supported. Additionally, supplier image (β = -0.398, p< 0.001) has a positive association with openness to change, therefore H2 is supported. Similarly, H3 also supported with openness to change (β = 0.445, p< 0.001), indicating a positive association with intention to use.

[76] classifies effect sizes of 0.02, 0.15, and 0.35 as small, medium, and large, respectively. Time constraint has a small effect on openness to change. Supplier image was found to have a medium effect on openness to change. In addition, openness to change has a medium effect on the intention to use parcel locker. Table 4 illustrates the results for the direct effect.

Table 4 Hypothesis testing for direct effect

Hypothesis	Relationship	Beta	SE	t-value	p-value	LL	UL	VIF	R^2	F^2
H1	**TC -> OTC**	-0.127	0.050	2.536	0.006	-0.205	-0.038	1.117	0.207	0.018
H2	**SI -> OTC**	0.398	0.050	8.016	0.001	0.313	0.476	1.117		0.178
H3	**OTC -> BI**	0.445	0.052	8.626	0.001	0.356	0.526	1.000	0.198	0.247

PLS Predict is a prediction analysis utilising a holdout sample-based approach with a 10-fold procedure to perform case-level predictions on an item or construct level and prove the predictive relevance [77]. When all item differences (PLS-LM) are less than the predictive relevance, strong predictive power is ascertained, moderate predictive power is ascertained when most item differences are less than the predictive relevance, and low predictive power is established when the minority of the item has a lower value [77]. Although, if all item differences are greater than the predictive relevance, high predictive power cannot be established. Results indicate that openness to change (SD, STI, and HED) has strong predictive power whereas intention to use exhibit predictive power cannot be confirmed. Table 5 illustrated the results for prediction.

Table 5 PLS Predict

Items	PLS RMSE	LM RMSE	PLS-LM	Q^2_predict
SD	**0.928**	**0.930**	**-0.002**	**0.146**
STI	**0.942**	**0.956**	**-0.014**	**0.121**
HED	**0.907**	**0.909**	**-0.002**	**0.185**
BI1	**1.339**	**1.171**	**0.167**	**0.161**
BI2	**1.306**	**1.104**	**0.202**	**0.166**
BI3	**1.362**	**1.185**	**0.177**	**0.148**

The outcomes of the mediation and moderation analysis are H4 and H5. A bootstrapping analysis was performed with a two-tail test setting. Table 6 shows that openness to change mediates the association between time constraints and intention to use, as well as the association between supplier image and intention to use. As a result, H4 and H5 are accepted.

Table 6 Hypothesis testing for mediation

Hypothesis	Relationship	Beta	SE	t-value	p-value	LL	UL	Decision
H4	**TC -> OTC -> BI**	-0.057	0.024	2.384	0.017	-0.103	-0.011	Supported
H5	**SI -> OTC -> BI**	0.177	0.036	4.976	0.001	0.111	0.251	Supported

5 Discussion and conclusions

The goal of this study was to discover the influencing factors of online buyers' intention to use automated parcel lockers in Malaysia. The SOR model was found to be useful in explaining customer behaviour. First, time constraint was found to be a negative predictor of openness to change in the current study, hence H1 is supported. As time constraint is one of the factors influencing user openness to change, the automated parcel locker provider should try to overcome the issue by eliminating factors such as location inconvenience. Spending more time to travel to retrieve the parcel at a designated parcel locker location can impair the online buyers' openness to change. The providers should place the locker close to the residential area, especially in the rural area., thus decreasing extra effort for travelling to urban areas. Reducing the time needed for a collection process will positively influence online buyers' openness to change and is crucial in helping the providers to attract customers.

Secondly, H2 was supported since supplier image was found to have a positive relationship on the openness to change. As the supplier image is one of the factors affecting openness to change, the service providers should enhance the company's image positively. Building a positive image is crucial in helping online buyers change their preferences from using the old method to using automated parcel lockers. Therefore, providing good services such as fast parcel delivery and keeping the parcel in good condition could contribute positively to enhancing the company's image. Besides, the automated parcel locker should be maintained in good condition to prevent any issues when customers are retrieving their parcels.

Third, openness to change was found to have a positive association with intention to use, indicating that H3 was supported, which is in accordant with prior studies by [54] and [55]. Therefore, the automated parcel locker provider should strive to influence online buyers' intention to use automated parcel lockers by targeting factors that influence their openness to change.

The study proposed mediation to further explain the study model. Openness to change acts as a mediator between association between time constraints and intention to use, as well as between the relationship between supplier image. The result confirms the mediation effect of openness to change on the relationship for the H4 and H5. Thus, these findings proved that openness to change is crucial in determining online buyers' intention to use automated parcel locker. Analysis for H4 indicates that the level of openness to change tends to decrease when online buyers perceived that they need to spend more time on parcel collection and; subsequently affecting their intention to use automated parcel locker. However, for H5, the result indicated that buyers who have a high level of openness to change and are aware of the good image of automated parcel locker providers are willing to use the automated parcel locker. Therefore, the provider which promotes the use of automated parcel locker focuses on empowering the online buyers with the company's good image. Additionally, the providers also need to strive to reduce the time accumulated for parcel collection in order to enhance the buyers' openness to change.

6 Theoretical and practical implications

Overall, the assessment of time constraint, supplier image, openness to change, and intention to use in the SOR model offers valuable insights regarding online buyers' intention to use automated parcel lockers. As a result, the SOR model suggested in this study has theoretical and practical implications in terms of predicting online buyers' intention to use.

In terms of theoretical implications, this study adds to the body of knowledge in the field of behavioural intention research by assessing openness to change on the intention to use automated parcel lockers in Malaysia. This study's SOR model is among the earliest to investigate the influence of time constraints, supplier image, and openness to change on online buyers' intention to use in a single study. The findings proved the existing model able to predict online buyers' behaviour, as well as guidance for future studies aimed at gaining a better understanding of the intention to use automated parcel lockers.

Besides, the current study confirmed time constraints and supplier image as factors affecting online buyers' cognitive process. As such, the current study created new links in consumer behaviour studies. Additionally, the mediation conducted provides strong evidence of time constraints and supplier image in shaping openness to change and intention to use, gaining new insight into online buyers' behaviour toward automated parcel lockers.

In terms of practicality, having a better comprehension of online buyer behaviour might be beneficial to the service providers in identifying the factors that influence intention to use. The factors proposed in the study offer decision-makers information about the elements that influence the online buyers' openness to change and, which can affect their behavioural intentions. The current study identified that time constraint and supplier image influence openness to change and subsequently influence intention to use.

These results imply that service providers should reduce online buyers' duration of travelling to parcel locker locations. Since the buyers are not opted to use the parcel locker if more time is needed for travel, it will impair their openness to change. However, online buyers are willing to use it if the parcel collection process requires less time to travel. Results confirmed that exhibiting a good image is crucial. The buyers are willing to change their preferences if the providers have a good image. Hence, current study identified that buyers will fostering a favourable openness to change toward using and automated parcel locker services when the service provider image is good and the parcel collection do not consume much time.

7 Limitation and future studies

There are certain limitations to the current study. Because the current study's model is based on Malaysian online buyers, it should be replicated in other countries with distinct cultures to extends its application and transferability. Furthermore, the SOR model was used in this study to investigate influencing factors for intention to use. As a result, examining online buyers' behavioural intentions to use automated parcel lockers from various theoretical viewpoints would enrich the literature. In addition, future study could expand on this model by include other factors that influence a person's willingness to use self-service technology, such as technology awareness and facilitating conditions.

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FROM CART TO LAYERED ARCHITECTURAL TRANSSHIPMENT MODEL SUPPORTING SMALL AND MEDIUM ENTERPRISES FOR ROAD FREIGHT LOGISTICS
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FROM CART TO LAYERED ARCHITECTURAL TRANSSHIPMENT MODEL SUPPORTING SMALL AND MEDIUM ENTERPRISES FOR ROAD FREIGHT LOGISTICS

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Keywords: road freight logistics, transshipment, layered architecture, small and medium enterprises.
Abstract: This study proposes a layered architecture of a transshipment model for small and medium enterprises (SME) that supports road freight logistics using rice farmers in Thailand as a case study. The rationale is three folds. First, road freight logistics transportation usually does not apply to SME. Second, existing supply chain logistics models are not appealing to SME in that SME do not have abundant resources to exploit the fullest extent of redeeming features of the models. Third, road freight logistics and transshipment are often incorporated as an integral service operation of a distribution centre to transport goods items from source to destination, which most SME cannot afford the entire service charge. The notion of layering is to make each layer transparent to one another, covering specific transshipment activities that do not overlap with adjacent layers yet keep their operating characteristics closely related. The case study of Thai rice farmers can thus operate and adjust to fit their working scenarios. Contributions of the proposed model are flexible and resilient operations that SME can benefit at less investment but more options to fall back on. Future work should emphasise on transshipment routing research and integration of the proposed model into distribution centre operations management.

1 Introduction

Ploughing has and is the basic farming operation to cut, break up, lift, and turn over the soil in preparing a seedbed. The good old buffalo pulling the plough was long gone in many parts of the world yet is still used in some countries. It is a cheap way, always works, and most important of all, environmentally friendly. Many farmers resort to mechanisation using a manual gasoline plough (aka 'iron-buffalo') or tractor-pull plough for transplant seeding. In this study, we will focus on rice farming. Farmers prepare a seedbed in April before the rainy season arrives in May to signal the plantation (rice is grown year-round in some fertile areas). When harvest time arrives, rice paddies are gathered on a cart pulled by a buffalo or a gas-operated cart to the shelter and subsequently transported to the mill by pick-ups or trucks. This family-style farming is slow, labour-intensive, and has low yields, but it is still practised in Thailand. As the number of farmers grows, a cooperative association for rice farmers is formed to assist and pool available resources together for larger-scale production. Higher bulks of paddies require more transportation trips to the mill, market, and consumers. This process is depicted in Figure 1, where the farmer begins at the cooperative association (1) to deposit their paddies. The paddies are dried, packed, and transported to market via gas-operated carts or private trucks (2). Transportation costs may vary depending on the rates charged by individual transportation businesses. The market includes agriculture outlets, middlemen, and wholesale (3) that distribute rice to consumers. Each transporting stage (1,2,3) is performed and kept track of manually on paper bookkeeping. At present, the shipment suffers from cost variation that raises the cost of goods sold. Unfortunately, farmers have no control on transportation costs to curb their expenditure.

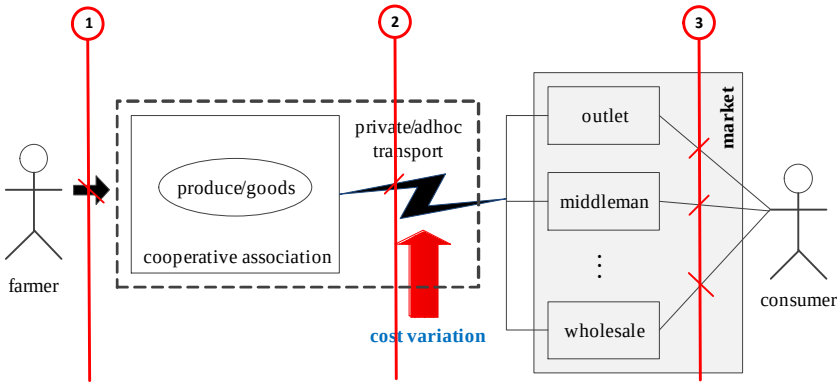

Figure 1 Manual rice farming and transport process

In today's world, buying the desired goods items is usually done online. The good old shopping from brick-and-mortar stores practice is less attractive for many reasons. Produce from the fields or products manufactured from the factories are delivered to consumers as efficient and timely as possible through various means and methods such as centralised and decentralised supply chain, joint distribution and transportation, vendor-managed inventory (VMI) [1] system, online shopping logistics [2], etc. Smaller logistics firms in the form of small and medium enterprises (SME) are popular transporters in the transportation business in many developing countries, such as the Association of Southeast Asian Nations (ASEAN), which will be further addressed in the next section.

As urbanisation grows, logistics sprawl [3] follows, as well as environmental laws and regulations are enforced to manage the safety of goods transport systems. Thus, logistics facilities must move farther away from populated areas. This inevitably incurs additional transportation charges to compensate for longer distances to and fro the sources of goods and destination recipients. To reduce such costs, high-capacity shipment by large container trucks is employed to save the transporting charge per goods item per trip. The need to set up transshipment points (TP), distribution centres (DC), or Urban Consolidation Centers (UCC), hereafter will be referred to as DC for brevity, for transferring the shipment using trucks (*Tr*) and pick-ups (*Pu*) to inner-city is necessary. This situation is shown in the third stage of Figure 1. Thus, this research work will focus on two issues as follow:

1. Serve to transport needs to and fro the city and rural areas, and
2. Utilise available data that can be locally deployed.

The rationale for each focus is straightforward. (1) There are many cost variables involved for DC that are too high a cost for any rice farmers or SME to bear such as building and equipment, rent, depreciation, goods damage claim, insurance, quality of service, digitisation of operations [4], environmental expenses, taxes, etc. (2) High-capacity cargo carried by truck or train from rice fields or rural manufacturing plants must end at DC on the outskirts of the urban area because limiting the capacity of urban transshipment is usually a mandate of today's urban planning. Concerns about the logistics sprawl [3] and environmental issues [5] call for a light-weighted and flexible model that permits operation or routing change for transportation logistics. More details will be elaborated in the sections that follow.

Contributions and benefits from the proposed model are two folds. From a research standpoint, future investigation on intelligent supporting operations and techniques are viable such as Artificial Intelligent based Global Positioning System or AI-based GPS, near-field communication technology (such as powerful and innovative RFID gadgets), and dynamic/capacitated vehicle routing problems (DVRP/CVRP) [6], etc. From a practical standpoint, several techniques and management precipitated from previous research can be implemented to accommodate, in this case, rice (or other products), transportation and transshipment that achieve efficient management of balanced fleet scorecard, backhaul assignments, collaborative distribution, and horizontal coalition management.

This paper is organised as follows. Section 2 recounts some related prior studies and the background of the research. Section 3 describes the research design that includes the relevant variables and cost functions. Empirical results and evaluation are demonstrated in Section 4. Some noteworthy points are discussed in Section 5. Section 6 concludes the study with some final thoughts and future work.

2 Literature review

This section will describe transportation logistics concerns, logistics scenarios for rice farmers, and their supply chain.

2.1 Transportation logistics concerns

Logistics transportation is an important component of the supply chain which involves many stakeholders. Transporting firms are minimising their expenses to keep the business afloat, while their customers (suppliers or manufacturers) are looking for inexpensive and trustworthy companies to send the goods to retailers and consumers. As technology progresses, it enriches transportation operations, planning of freight forwarding coalitions to improve profitability [7], flexibility and cost allocation mechanisms for optimisation, and cheaper distribution plans [8].

The redistribution of transporting across organisations with the help of digitisation would encapsulate operations and supply chain management such as additive manufacturing that enabled design, manufacturing, delivery, and use [4]. From finer organisational logistics granularity, transporting among (material) suppliers themselves, suppliers and manufacturers, wholesalers and retailers could be viewed as a buyer's role who utilised logistics companies as a supplier role to move their products through various logistics channels. This buyer-supplier relationship would call for a mechanism of operational coordination and financial collaboration. Cheung et al. [9] found that the presence of Common Institutional Investors (CII) improved suppliers' operating and market performance. As companies grow, innovation activities within their supply networks increase. They could exchange products, services, R&D data, and other resources to balance the efficiency and resilience of network characteristics, network mechanisms, and innovation outcomes.

To better understand the environment, business, strategy, process, and information systems, Osterwalder et al. [10] proposed the business model ontology that supported a design science approach. Issues such as legal

and social environments, customer's demand, technology change, and competitive forces were important considerations to heed. Aljohani et al. [3] defined logistics sprawl, freight sprawl, and logistics polarisation, reviewing their effect on environment of local community due to truck traffic congestion, noise, air quality, and safety. On the other hand, for logistics companies and freight industry, facility location impacted on transport costs and efficiency of operations. Taniguchi et al. [5] surveyed several pertinent UCC and TP cost factors in Tokyo and Bordeaux for sustainable and liveable city logistics. They were cost reduction, congestion alleviation, noise reduction, greenhouse gas (GHG) emission reduction, fuel consumption reduction, empty move reduction, travelled distance reduction, service quality improvement, and fill rate improvement. The size, weight, composition, and many special requirements also imposed additional mandate to the transporting form such as bulky materials, over-sized shipment, perishable items, hazardous liquid or gas composition, etc. These environmental and social responsibilities posed the capital dimension to suppliers especially for multinational companies [11].

One minor but specific factor that affects logistics transportation is weather risk for the coordinating supply chains, reducing cash-flow uncertainty, potential lost sales to the next tier [12], and rice quality if they are wet. The application of their proposed methodology led to the selection of the critical day and temperature as the most influential variable on sales. These influential transportation factors would be taken into account for the transshipment model that fits SME logistics industries in Thailand since it is located in the tropical region.

A regional transportation mandate that affects cost consideration of the proposed transshipment model is truckload (TL) driver issue. Kutac et al. [13] investigated the impact of personnel costs on road freight transport companies that would be considered for the proposed model design. Unlike most industrialised nations where the driver is the sole operator of a given TL transport, Thailand, as well as the ASEAN, utilises an additional driver helper to improve transport service quality and safety which are required by "Service Quality Standard for Truck Operation" (Q-mark handbook) [14] of The Department of Land Transport (DLT), Ministry of Transport (MOT). The standard complies by The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Resolution 48/11 on Road and Rail Transport Modes in Relation to Facilitation Measures for operations in the sub-regional transport under The Greater Mekong Subregion (GMS) Program, GMS Cross-Border Transport Agreement (CBTA). Figure 2 shows the transportation routes in the region. All routes connect only those countries located on the Southeast Asia peninsular, namely, Thailand, Myanmar, Laos, Vietnam, Cambodia, Malaysia, and Singapore. The remaining ASEAN members are islanders and not connected by land routes, i.e., Brunei Darsussalam, Indonesia, and the Philippines.

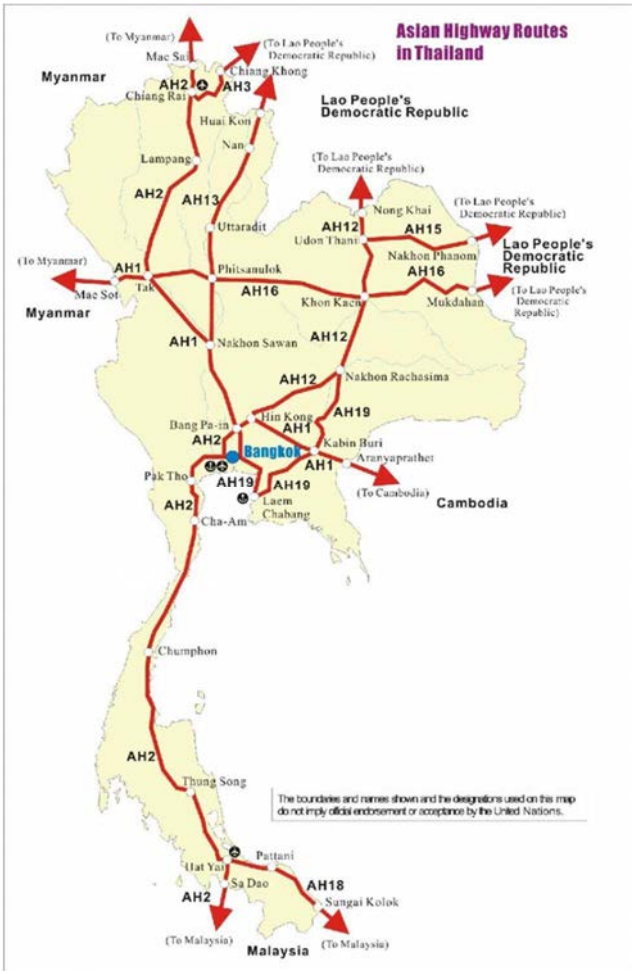

Figure 2 CBTA transportation routes

Miller et al. [15] unveiled the relationship between TL motor carrier size and productivity. They proposed (1) increasing returns to scale for carriers with low technical efficiency, (2) constant returns to scale for carriers with average technical efficiency, and (3) decreasing returns to scale for carriers with high technical efficiency. Their findings contributed valuable implications for the logistics literature, carrier management, and other industry stakeholders.

2.2 Logistics environment for rice farmers

Logistics has been playing an important role in supply chain management (SCM) ever since myriad of modern SCM tools and techniques are put into practice. Effective logistics management offers up-to-date status tracking that drives the cost of transportation down. Bramel et al. [12] addressed the technologies that motivated the management of logistics systems, namely, mobile communication and overnight delivery. This matched the heightened demands with short-notice order placement to get timely shipments of fresh produce to market. In general, truck and rail transports are the main vehicles of agricultural goods

shipment. Nonetheless, small trucks or pick-ups are preferred means by Thai farmers since they conveniently move goods directly from source (farm) to destination (market).

There are several small-sized transshipment logistics service providers (LSP) that run their business to and fro DC and inner city. Most of them bundle their resources and cooperate with larger-sized LSP to serve a wide array of logistics operations, ranging from packaging in omni-channel [4] to large items. As they tender on large items, they can resort to horizontal cooperation for handling this temporary contract. For example, transshipping rice sacks is done by mid-sized trucks carried out by one of the larger-sized cooperating LSP. This is akin to omni-channel retailers who guide their customers about product availability across channel into physical store [16]. Son et al. [1] studied the incentive-aligned contractual arrangement between vendor and multiple retailers and reallocation of fixed shipping cost could benefit the vendor managed inventory (VMI) system. The dynamics of different supply chain design and policy parameters could be applied to inventory and replenishment decisions at locally managed inventory (LMI) installation in a decentralised manner. This essentially resembles rice farming and transport process of Figure 1.

2.3 *The supply chain of rice*

The supply chain of rice has a straightforward flow categorised by Sowcharoensuk [17] as shown in Figure 3. We will describe the flow in three stages, namely, (*i*) upstream representing activity in rice field, (*ii*) midstream representing production process of rice mill, and (*iii*) downstream representing broker, domestic and export markets. Stage (i) is the ploughing until harvest. Stage (ii) encompasses three buying channels, i.e., agriculture cooperatives, paddy rice centre market, and paddy rice collectors that independently buy rice paddies and feed to rice mills. Stage (iii) illustrates polished rice from mill to be transported to broker/distribution centre, exporter, wholesaler, and rice packer. The broker in turn could either sell to exporter or wholesaler, while wholesaler can either sell to retail stores or rice packers, both of whom sell to final consumers.

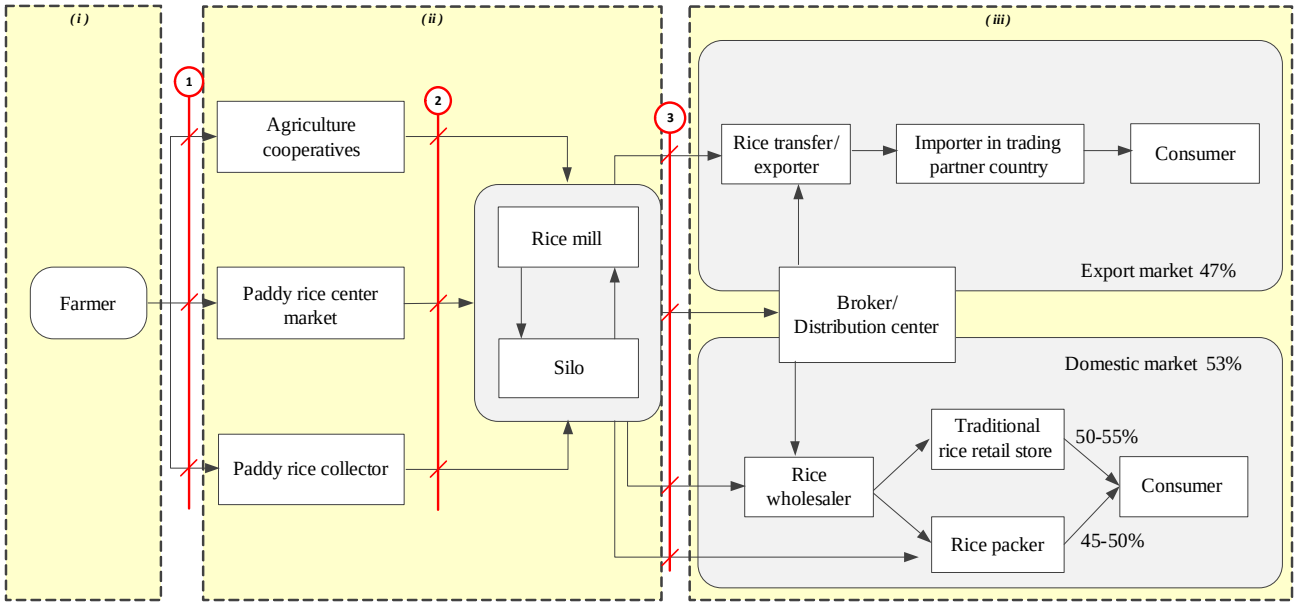

Figure 3 Thai rice supply chain
Source: Trade map, Ministry of Commerce (MOC) and compiled by Krungsri Research [17]

One of the problems contributing to ineffective supply chain is the lack of silo on the farmers' part. As they cannot afford building their own silo, they must sell their produce after harvest. The process of transporting paddy rice is inefficient and costly. We added three vertical lines 1,2,3 to denote our focus on transportation logistics at the slash-mark intersecting points. Line 1 denotes transportation logistics of paddy rice from rice field to primary buyers. Line 2 denotes transportation logistics of paddy rice from primary buyers to rice mill. Line 3 denotes transportation logistics of polished or milled rice from rice mills to all downstream resellers and consumers. Albertzeth et al. [18] evaluated four mitigation strategies in supply chain disruption for distribution centre and retail stores. They identified six types of supply chain disruptions, namely, supply, demand, transportation, facilities, and communications. These will be used in costing assessment of the proposed model.

3 Research design

We propose a working model encompassing operation strategies that prioritise resilience of the logistics structure, resource planning, and costs. Details are described below.

3.1 The cost of transportation

The issues pertaining to agricultural supply chain logistics have been investigated in-depth by Bae et al. [19] that identified internal orientation and market orientation. Their findings coincided with existing practices that made considerable progress in logistics SCM for rice farming. Figure 4 further elaborates on the cost of transportation from Figure 3 where farmers sell paddies (1) to rice mill. These milled rices are kept in the silo and subsequently packed in different weighing sacks (2). Transporting rice sacks is then arranged to many DCs for further distribution to retailers, grocers (3), and eventually consumers. The important accounting process is the cost function encompassing fixed costs (storage, equipment), variable costs (number of sacks, labour), and transportation cost. This study focuses on transportation cost structure and characteristic with the logistics supply chains, i.e., shipment from rice mill to DC and retail stores.

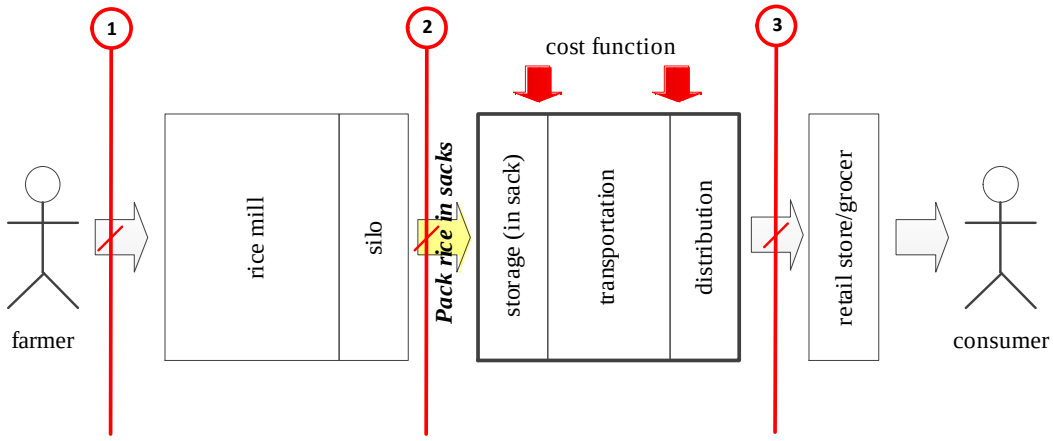

Figure 4 Cost of rice transportation logistics

3.2 Initial development

A number of operational variables to be used in the proposed model are established as follows:

1. Objective of transport
2. Region of coverage
3. Transport distance
4. Transport volume
5. Allocation of transshipment vehicle

These variables are directly or indirectly tied based on fixed cost and variable cost involved in administering the transshipment. Derivation of the cost function will be described in the next section.

The first variable denotes the purpose of transport to be set up in two operations, namely, regular and special transport operations. Regular transport handles all types of requests except special transport requests such as perishable goods items or express packages that must be air freighted or rapid delivery. The second variable designates regions of transportation coverage. There are only two regions in this study, i.e., rural and city. The former represents goods items from trucks hauling bulk shipment from supplier or manufacturer to DC, while the latter represents *Pu* transporting goods items from DC to city warehouse, store, or consumer. The third variable denotes distance of goods items to be transported. The fourth variable denotes volume or payload of goods items per trip. The fifth variable denotes allocation or assignment of transshipped vehicles.

We propose a transshipment model incorporating the above operational variables into multi-relation variables that are prioritised as shown in Figure 5. Design considerations are divided into two views, namely, *vertical view* denoting management of regional coverage and information system and *horizontal view* denoting operational classifications. Details are described below.

The vertical view is divided into three sections, namely, left, middle, and right. The left section represents input data to the proposed model such as large/periodic, small/frequent, and air freight. The middle section represents activities and operations in DC. The right section represents the outputs such as long, short, inner city, and special. Note that this flow process can be reversed because items (rice sacks, products, etc.) can be sent from right side (input) back to left side (output) for returned items or special request situation.

The DC is divided into two sides, namely, rural and city sides. Transfer operations of goods items passing through DC include drop-off, pick-up, and temporarily storage. Scheduling and transport precedence are performed by DC which are beyond the scope of this study but will be demonstrated by a case of scheduling precedence relation below.

The horizontal view is divided into four operation layers. The first layer is a special transshipment service that

FROM CART TO LAYERED ARCHITECTURAL TRANSSHIPMENT MODEL SUPPORTING SMALL AND MEDIUM ENTERPRISES FOR ROAD FREIGHT LOGISTICS

Nalinee Sophatsathit

requires, in most cases, special/express transshipment and delivery. Inputs are usually air freighted and transshipped by *Pu* to the destination, which may or may not be transshipped at the DC depending on the imposing requirements such as urgent shipments or perishable goods items. The dotted connecting line and dotted region boundary depict this DC bypassing scenario. The transport direction can go both ways since the reversed input (dotted input arrow) depicts shipment from city to rural side for out-of-town air freighted request.

The second layer represents frequent but small load of transport between inner city and rural areas. This set up serves the purpose for a rapid and efficient goods movement. Note that the arrows between the first layer and this second layer are management provisions for sharing individual *Pu* to transship late arriving special/express items, thereby maintaining smaller operating fleet.

The third layer or short haul denotes large but periodic transporting of goods between rural but close to city area. The short haul may deploy *Pu** from the rural pick-up point if the volume is not too large. The exploded view depicts how request exchange, either regular or chartered (special or ad hoc) request, is handled at the DC during transshipment from *Tr* or *Pu* to the designated *Pu**.

The fourth layer or long haul is usually large and high volume but periodic that requires trucks to transport to save transportation cost per trip. The arrows in the DC designate transshipment from *Tr* by unloading goods on to a *Pu*, or reloading from *Pu* to *Tr* in case shipping from city to rural area. This principally incurs the heaviest transshipment activities as noted by dotted circles. The rationale is straightforward. The sooner large volume of goods is out of DC, the more savings of transportation and storage costs will be.

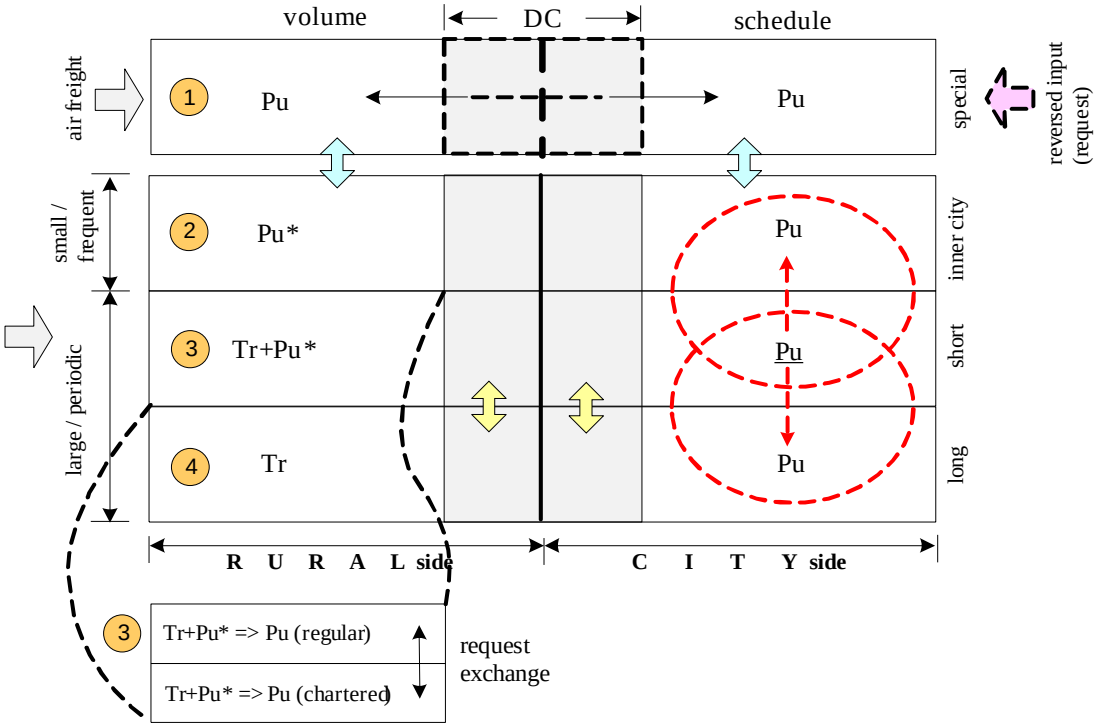

Figure 5 The proposed transshipment model

This layer organisation makes individual layer transparent from one another. It also offers resilient fallback between adjacent layer should the immediate layer encounter any transshipment problems. For example, a moderate sized DC might not need to setup the third layer or short haul so as to scale down its operation for cost savings. In which case, the *Tr+Pu** input could be split by moving the truck sub-fleet to combine with those of the long-haul layer, while the *Pu** which are routinely shared with the second layer could entirely move to serve that layer. Thus, only three layers remain in operation, that is, 1, 2, and 4. At any rate, managing transporting fleet schedule, DC operating manpower/schedule, personnel administration, equipment and facilities utilisation, etc., are beyond the scope of this study.

A loose end notes on the above vertical view of DC transport precedence that imposes a transshipment item to be dropped off and re-scheduled for transshipment is elaborated here. The order of item precedence regulates the schedule of transshipment. That is to say, operational serialisation must be strictly observed, with the exception of the special transshipment service (first layer) that requires direct end-to-end transport without stopping over at DC. Consider a DC time window schedule problem [20] demonstrated below (denote: +get/-retrieve [operation time window]: service time).

A ⟶ $r1^+$[0,10]:10 – $r4^-$[50, 150]:10
B ⟶ $r4^+$[0,20]:10 – $r1^-$[60, 100]:10
$r5^+$[0,20]:10 – $r6^-$[65, 120]:10

Two schedules {A – **r1**$^+$ – TP – **r4**$^-$ – A} and {B – **r4**$^+$ – TP – **r1**$^-$ – **r6**$^-$ – B} mean A gets **r1**$^+$ no later than 10, transports it to TP, and retrieves **r4**$^-$ from TP no sooner than 50, while B gets **r4**$^+$ and **r5**$^+$ no later than 20, transports them to TP, and retrieves **r1**$^-$ and **r6**$^-$ from TP no sooner than 60 and 65, respectively.

If we imposed the transport schedule precedence among **r1**$^-$, **r4**$^-$, **r5**$^-$, and **r6**$^-$, B could retrieve **r1**$^-$ and **r6**$^-$ from TP, reducing delays of 60-50=10 and 65-50=15 units of the latest schedule, respectively. This time window scheduling could be theoretically easy to adjust but somewhat difficult to work out in practice because of driver's tardiness, traffic congestion, and other unexpected delay situations that could throw out such a tight transshipment time window at TP and worsen the operating schedule of the transporting fleet.

3.3 Cost consideration

One of the principal transportation costs of the proposed transshipment model is *Tr* and *Pu* driver and helper rates. As Miller et al. [15] described several reasons for driver helper and the aforementioned Q-mark handbook requirements, we procedurally incorporate these driver and helper rates into transportation cost consideration. The general cost function of the proposed transshipment model is setup by separating *Tr* and *Pu* factors for explicit costing classification and subsequent analyses as follows.

$$C_1 = D \times w_1 + T \times w_2 + V \times w_3 + L \times w_4 + F \qquad (1)$$

where C_1 denotes the transshipment cost; D = {D_p, D_t}, D_p and D_t denote distance (km) covered by *Pu* and *Tr*, respectively; T = {T_p, T_t}, T_p and T_t denote time (hr) spent by *Pu* and *Tr*, respectively; V = {V_p, V_t}, V_p and V_t denote volume of payload (cu.m) carried by *Pu* and *Tr*, respectively; L = {L_p, L_t}, L_p and L_t denote weight (ton) of payload carried by *Pu* and *Tr*, respectively; F = {F_p, F_t}, F_p and F_t denote fixed depreciated cost (Munit) of *Pu* and *Tr*, respectively; and w_i, i=1, 2, …, 4 denote Munit/km, Munit/hr, Munit/cu.m, and Munit/ton fixed charges that are applicable to *Pu* and *Tr*, respectively. Note that these factors are not broken down into finer details so as to keep cost analysis flexible for subsequent adjustments to fit the regional or domain of applications. For example, in Thailand, factor T may include weather conditions influence [12] when 'monsoon' arrives in May and ends in late October. Often time this flash flood will cause paralying traffic to and fro the city and DC. Similarly, road detour due to maintenance, special events, accidents, will result in routing and schedule change to accommodate the adhoc situation, thereby affecting both D and T factors.

The wages of driver and transport assistance are setup as follows.

$$C_2 = R \times D + S \times T \qquad (2)$$

where C_2 denotes the wages; R = {R_p, R_t}, R_p and R_t denote *Pu* and *Tr* fuel and maintenance expenses (Munit/km) handled by the driver and helper; S = {S_{p1}, S_{p2}, S_{t1}, S_{t2}}, S_{p1}, S_{p2}, S_{t1}, and S_{t2} denote *Pu* driver's, *Pu* transport assistance wages (Munit/hr), and *Tr* driver's, *Tr* transport assistance wages (Munit/hr), respectively. Care must be taken for wage increase since it will impact labour productivity in terms of sales per employee and company's profit [13].

The overall fleet allocation cost to be fed in DC for further detailed breakdown is as follows.

$$C_3 = O_p N_{pE} H_{pE} + [O_p N_{pCS} H_{pCS} + O_t N_{tS} H_{tS}] + O_t N_{tG} H_{tG} \quad (3)$$

where O_p denotes proportional *Pu* allocation; O_t denotes proportional *Tr* allocation; N_{pE}, N_{pCS}, N_{tS}, and N_{tG} denote the number of *Pu* and *Tr* to be allocated for express (special) delivery(E), inner city and short haul(CS) *Pu pool*, short haul(S) truck, and long haul(G) truck, respectively; H_{pE} denotes the first layer *Pu* allocation costs that set aside for express delivery; H_{pCS} denotes second and third layer *Pu pooling* allocation costs, wherein the *Pu* pool can be shared between inner city and short haul services; H_{tS} denotes third layer (short haul) *Tr* allocation costs, and H_{tG} denotes the fourth layer (long haul) *Tr* allocation costs, respectively. This setup permits provision for outsourcing of the *Pu* pool (and optionally *Tr* pool in short haul operation) by various SME logistics which is a common practice in many countries, while those SME can still run their own express and long haul truck operation. Thus, the second and third terms of Eq(3) can be combined into one lump sum as shown in Eq(3)'.

$$C_3 = O_p N_{pE} H_{pE} + X_S + O_t N_{tG} H_{tG} \qquad (3)'$$

where X_S denotes the external sourcing expenses as the result of resilient operational consolidation. Hence, the total cost (TC) becomes

$$TC = C_1 + C_2 + C_3 \qquad (4)$$

3.4 Preliminary cost evaluation

To demonstrate computations of the total cost, let's consider a *Pu* transshipment from rural area to inner city request. The cost analysis is determined as follows (in monetary term denoted by Munit).

$C_1 = D_p \times w_1 + T_p \times w_2 + V_p \times w_3 + L_p \times w_4 + F_p$
$= 30 \times 3.5 + 1 \times 5 + 2 \times 2 + 1.2 \times 4 + 2.08$
$= 105 + 5 + 4 + 4.8 + 2.08$
$= 120.88$ Munits

and

$C_2 = R_p \times D_p + S_{p1} \times T_p + S_{p2} \times T_p$
$= 0.45 \times 30 + 5 \times 1 + 3 \times 1$
$= 13.50 + 5 + 3$
$= 21.50$ Munits

and
$C_3 = O_p N_{pCS} H_{pCS}$
$= 0.02 \times 16 \times 2.4$
$= 0.77$ Munits

Therefore, we have
TC = 120.88 + 21.50 + 0.77
= 143.15 Munits

where D_p=30 km, w_1=3.5 Munits/km, T_p=1 hour (rounded up to hour), w_2=5 Munits/hr., V_p=2 m^3, w_3=2 Munits/m^3, L_p=1.2 tons, w_4=4 Munits/ton, F_p=2.08 Munits (500Munits/30days/8hrs=2.08 Munits), R_p=0.45 Munits/km (0.31 gas+0.14 tire), S_{p1}=5 Munits, S_{p2}=3 Munits, O_p=0.02, N_{pCS} =16, H_{pCS}=2.4 Munits.

4 Empirical results

Due to confidentiality of personal and company data protection, we selected descriptive statistics being compiled from public reports of the Thai Transportation & Logistics Association [21], Transport Statistics Group, Department of Land Transport [22], International Transport Service Providers [23], and SME such as XYZ express, and ABC company [24], etc. (their identities were withheld for confidentiality and privacy reasons). Standard measurements of the statistics are given in Table 1, e.g., the dimensions of a 20 feet tunnel container are 6.06 × 2.59 × 2.44 cu.m, *Pu* and *Tr* fuel and maintenance expenses are 0.45 and 0.97 THB/km, respectively. Table 2 provides some basic conversions of rice sacks to be used in payload computations.

Table 1 Parameter constants

Variable	Value	Remark
V_p	6.48	$1.8 \times 2.0 \times 1.8$ cm^3
V_t	38.30	$6.06 \times 2.44 \times 2.59$ cm^3 (20 ft: $20 \times 8 \times 8.5$)
L_p	1.60	ton
L_t	30.00	ton
S_{p1}	166.67	THB
S_{p2}	150.00	THB
S_{t1}	292.05	THB
S_{t2}	262.84	THB
F_p	2358.33	THB
F_t	3787.88	THB
R_p	0.45	THB/km
R_t	0.97	THB/km

Table 2 Some basic data conversions

1 sack of rice	100 kgs	1 Large truck	50 tonnage payload
1 tonnage	1000 kgs	1 Small truck	1.1 tonnage payload

We utilised available data from local rice farmer's cooperative that operated as an SME of rice supply chain. We adapted the proposed model to analyse logistics of this cooperative by using three operating scenarios that fit road freight capabilities as follow: ({*n*} denotes the model's layer, *n*=1, 2, 3, 4)

a) Ran small/frequent transportation and transshipment in-house: {2},
b) Ran small/frequent transportation and transshipment by outsourcing: {2}, and
c) Ran short haul transportation and transshipment by coalition transshipment: {2} + {3}.

The first two scenarios (a) and (b) operated according to Figure 1 using moderate size *Pu* fleets. The bulky nature of rice paddies required more *Pu* to transport them from rice field to rice mill than from the rice mill to DC and community markets since milled rice were filled in sacks. Thus, the need for number of *Pu* varied depending on main or off harvest seasons since rice were grown year-round. This was apparent from boosted sales of pick-ups last year, i.e., 6,878,050 units [22]. Some farmers outsourced to local SME to curb their capital investment. Table 3 lists a few well-known local SME and international parcel delivery companies. Their service coverage includes drop off and pick up requests, price estimation, self-collection, online claims, etc. Most of them operate their own DC locating nation-wide. However, statistics pertaining to their operating costs are not made available to public. Thus, we employed the norm Eq(1) + (2) + (3) and Eq(1) + (2) + (3)' in the cost consideration as shown Table 4.

The third scenario (c) represented conventional transshipment and logistics that transported to (i) domestic SME using small to moderate *Pu* and *Tr* fleets, and (ii) international companies in GMS region using moderate to large *Tr* fleet. However, we only focused on domestic SME in this study. These SME are usually small in terms of capital investment, resources, and service coverage. Some of them operated coalition service, particularly when transporting large number of rice sacks or bulky goods items. We considered such coalition services as outsourcing requests, wherein employing Eq(1) + (2) + (3)' in the cost consideration as shown in Table 5.

Table 3 Express service company list

Domestic	International
Thailand Post, Shippop [25], Inter Express Logistics, TP Logistics, Por Lor Express, Nim Express, Alpha Fast, Sendit [26].	**Kerry Express, FedEx Express, DHL, Yusen Logistics, Ninja Van, SCG Express, J&T Express, ZTO Express, CJ Logistics [26], Flash, FastShip.**

Table 4 Estimated operational statistics of SME of scenario (a) and (b)

d_p	d_t	t_p	t_t	v_p	v_t	l_p	l_t	C_1	C_2	N_E	N_{CS}	N_S	N_L	C_3	TC
77	328	5.9	7.5	3.7	33.4	1.2	25.8	8,146.3	6,382.8	2	16	8	13	268.9	14,771.4
87	342	5.7	7.6	4.6	35.1	1.0	27.9	8,354.2	6,393.0	4	19	6	11	219.8	14,947.1
86	293	6.2	7.7	3.8	31.6	0.9	26.6	7,932.9	6,558.9	3	20	7	14	272.2	14,740.6

Table 5 Estimated operational statistics of SME of scenario (c)

d_p	d_t	t_p	t_t	v_p	v_t	l_p	l_t	C_1	C_2	N_E	Xs	N_L	C_3'	TC
80	328	6.0	8.0	5.1	34.6	0.9	28.6	8,189.8	6,693.3	3	61.9	11	214.9	15,097.9
75	287	5.8	7.6	4.8	32.6	0.7	26.3	7,806.6	6,365.9	3	54.2	10	193.4	14,365.9
91	315	6.1	7.9	3.9	36.8	0.6	27.2	8,175.4	6,661.8	4	46.4	12	213.5	15,050.7

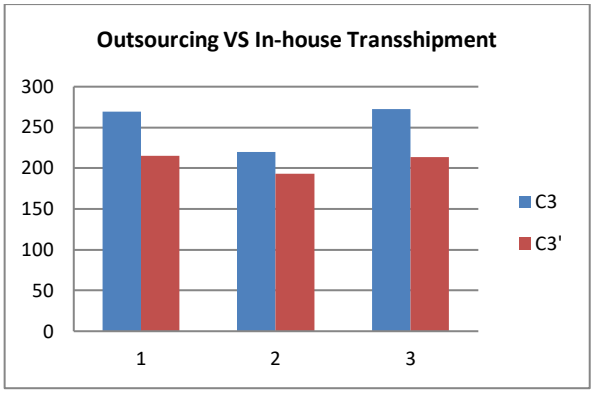

Figure 6 Outsourcing VS In-house cost comparison

Figure 6 depicts cost comparison between outsourcing and in-house transshipment consideration which do not reflect any significant savings, i.e., the costs of operating city *Pu* ($O_pN_{pCS}H_{pCS}$) and short haul trucks ($O_tN_{tS}H_{tS}$) obtained from Eq(C3) are slightly higher than outsourcing lump sum from Eq(C3'). Nevertheless, some indirect savings of outsourcing other than capital investment lie in the overhead such as car insurance, maintenance, depreciation, fuel, direct and indirect driver costs, labour relations and management, etc. Some of these overheads are out of the scope of this study.

5 Discussion

We have established a layered transshipment model operating flexible management schemes to cover road freight capabilities that are applicable to SME since they are the principal logistics service providers for Thai rice farmers. The model practical implication is to furnish resilient strategies that can be prioritised to suit the general use. There are several noteworthy issues to be further discussed.

Firstly, the proposed model was resilience and practical to utilise available data to be deployed. The hierarchical layered architecture permitted operational shift to adjacent layer that suits the service capability. For example, one multi-branch SME operated a small city sub-branch (limited by the available space) and a spacious sub-urban branch to handle layer 1 and layer 2, respectively. They could share the *Pu* fleet depending on the service load of each sub-branch. From time to time, shortage of *Pu* might occur during harvest season as the sub-urban branch was overloaded, but could not transfer all available *Pu* from the city branch to keep the service obligation of layer 1. Different course of actions could be taken such as adding new *Pu* (if budget permits), running for freight forwarding coalition, or hiring more drivers to fully operate existing *Pu* fleet. Truck driver issue has posted some occupation problems such as wages and demographic change, unfavorable social status, and working conditions [27]. Additional compensations could be paid but would increase personnel cost and decrease sale per employee and company profit. Consequently, personnel administration and operation management would be expensive and inevitably disruptive to road freight logistics.

Secondly, outsourcing and in-house issues had been studied extensively where outsourcing was practically suitable for certain scenarios. In addition to the above outsourcing cost comparison, the issue could be further explained by an operational case in point. A small sized SME in the second layer could operate on a handful of *Pu*, having only minimal IT equipment installed to meet local regulation mandate. They would be reluctant to add state-of-the-practice gadgets that helped meet the Q-mark handbook, thereby the operating cost was minimal. As technology progresses, so do regulations and standards change. Keeping abreast with these issues was expensive. They moved to outsourcing because it would offer more selections, price competitiveness, having no maintenance and other operating costs involved, no labour relation problems, employee benefits/compensations, and most

important of all, the driver occupation problems. On the contrary, a moderate sized SME (having less financial limitations) in the same echelon might recognise service expansion opportunity and the urgency of digital transformation that brought about fast and innovative methods to improve existing operations and raise the quality of road freight transport. Thus, operating in-house transshipment by exploiting the layered architecture of the proposed model would allow more control and broaden their operational scope from local transportation to international transportation and logistics firm. As a result, they could become a quality LSP.

Thirdly, some local SME in layer 2 were still running an intangible 'family style' personnel administration. Their employees were on a life-time employment, receiving free of charge accommodations, subsidised meals in the company canteen, etc. Such offers might apply to immediate family members of the employee as well. Consequently, turn-over rate was low. What seemingly low incentive wage in Thailand by industrialised countries' standards was invaluably offset by the above tradition. Nonetheless, we only took the wage factor into cost consideration since this old-fashioned tradition was gradually diminishing.

Fourthly, the proposed model does not incorporate DC operations into consideration. Thus, complete analyses of logistics and transportation supply chain (such as schedule precedence demonstrated earlier) are not supported. This exclusion actually fits Thai SME logistics and transportation expenditure (which account for 15.7% of their total expenses) since SME constitute 99.5% of the country business establishments that make up 35.3% of Gross Domestic Product or GDP [28].

We have demonstrated the viability of the proposed layered architectural transshipment model that satisfies the above two research focuses, i.e., between city and rural areas by utilising local data with the help of a case study. Moreover, the applicability of the proposed model does not confine to rice or agricultural produce, but should fit well with general products. In fact, during the COVID-19 pandemic locked down that has created huge volume of online orders and deliveries, most of the express service companies (listed in Table 3) performed successfully to meet such escalating demands. Although we could not obtain any performance statistics owing to their trade confidentiality, we envisioned that the resilience of the proposed model would not only offer flexible and cost saving fleet management, but also would serve as an efficient SME road freight logistics framework.

6 Conclusion and future work

We presented a transshipment model for SME that was supposedly adjustable to different working scenarios. The layered architecture with resilience operations management and resource sharing furnished a realisable and practical framework for SME to co-exist with DC. Thai rice farmers data were compiled and plugged into the model for a preliminary validation. Although the savings turned out to be moderate, a few innumerable aspects of cost consideration and applicability were argued at length. Contributions to transshipment and logistics of road freight transport are many folds. For example, it will help raise service quality standard for *Tr* and *Pu* operations, foster the potential and capacity of transshipment and logistics systems in the hands of SME to support trade sectors, and serve as a tool for value added SME when seeking for better or new business prospectus. The resilience of the proposed model not only fits many SME operations in Thailand and GMS countries, but also is cost effective to SME in industrialised countries.

Future work should focus on some of the following open issues. (1) treatment in the V and L factors for extended coverage using other transshipment models such as DVRP, CVRP, Split VRP (SVRP), and multi-product cross-docking SVRP [6]. The outcomes will certainly be conducive toward efficient and cost effective planning and scheduling of *Tr* and *Pu* transshipment, logistics, and management of DC, such as elimination of scheduling delay or duplication, standardisation of route assignment, reduction of downtime and rework, etc.; (2) integration of transshipment logistics into DC as a one-stop operations management hub and the cost involved; and (3) transform the model into a software tool that will support service quality for the road freight industry and customers who are seeking for qualified logistics operators.

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PRIORITY STRATEGIES SELECTION TO PREVENT MIDDLEMEN DOMINATION IN SHORTENING THE DISTRIBUTION CHAIN

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Keywords: distribution chain, AHP, Liberatore, seaweed, middlemen (tengkulak).
Abstract: Seram Bagian Barat (SBB) Regency is a good location for seaweed cultivation in Maluku Province. The area of land and the amount of seaweed production in the area is vast. However, in one of the giant seaweed-producing areas, the lives of most seaweed farming communities are still below the poverty line and are not prosperous due to the long distribution chain and the dominance of middlemen's role in their business still huge. This study aims to analyse and obtain the best-prioritized strategy to overcome the dominance of middlemen (called tengkulak) in seaweed cultivation using the Analytical Hierarchy Process (AHP) method with the Liberatore approach. From the results of data processing, it was obtained that the best strategy that became a priority for the prevention of domination in seaweed cultivation was the strategy Utilizing marketplaces or digital marketing with the highest weight of 0.483, followed by the strategy Expanding the Role of Regional Companies in Marketing at the Provincial and District with a weight of 0.241, the strategy Activating Cooperatives on a District Scale with a weight of 0.224. The last one is the strategy The Department of Industry and Trade Regulates the Overall Chain of Commerce" with a weight of 0.036. These results can be used as the basis for policymaking for the Seram Bagian Barat Regency government in shortening the seaweed distribution chain as one of the superior regional commodities so that it can improve the performance of the seaweed supply chain in the future.

1 Introduction

The Central Statistics Agency for Maluku Province shows that the total seaweed production in Maluku Province in 2020 is 71,928.65 tons with a production value of Rp. 224,634,529,000 [1]. Although Maluku Province is one of the largest seaweed-producing areas in Indonesia, the lives of most of the coastal communities are below the poverty line and are still not prosperous. Based on previous research [2-4] explains that the marketing chain for seaweed cultivation consists of nodes of local traders or middlemen, middle or inter-island traders, and exporters, which are almost the same model for the type of seaweed in Indonesia, which is shown in Figure 1.

The seaweed marketing chain's length causes the product's purchase price at the farmer level to be very low, where the price per kilogram is Rp. 8,000 to Rp. 10,000. Meanwhile, the selling price to advanced consumers is Rp. 24,000 up to Rp. 32,000 higher than the price at the farm level, so there is a significant price disparity of 65%-68.75% (source: data processed from various sources). This is also supported by the research of [5] regarding the value chain of seaweed distribution on the island of Tarakan, which shows a significant price disparity between farmers and exporters. The low price of seaweed makes cultivators feel disappointed because the price offered is not commensurate with the hard work they have done so far. Even some farmers hold their seaweed products for sale for the same reason, namely the price is too low [6]. Seaweed cultivation is a mainstay business for coastal communities in Seram Bagian Barat (SBB) Regency, so it has a very immediate impact on improving welfare and increasing the rate of community economic growth.

From the description above, analysing the selection of middlemen prevention strategies is necessary to shorten the seaweed distribution chain in Seram Bagian Barat Regency. Therefore, this study aims to find the best strategy, which is a priority for preventing the dominance of middlemen in seaweed cultivation in the Seram Bagian

Barat (SBB) Regency. The results of this study are expected to be applied in policy-making to protect seaweed farmers against middlemen, improve the welfare of seaweed farmers and empower coastal communities, and can be used to alleviate poverty in Indonesia.

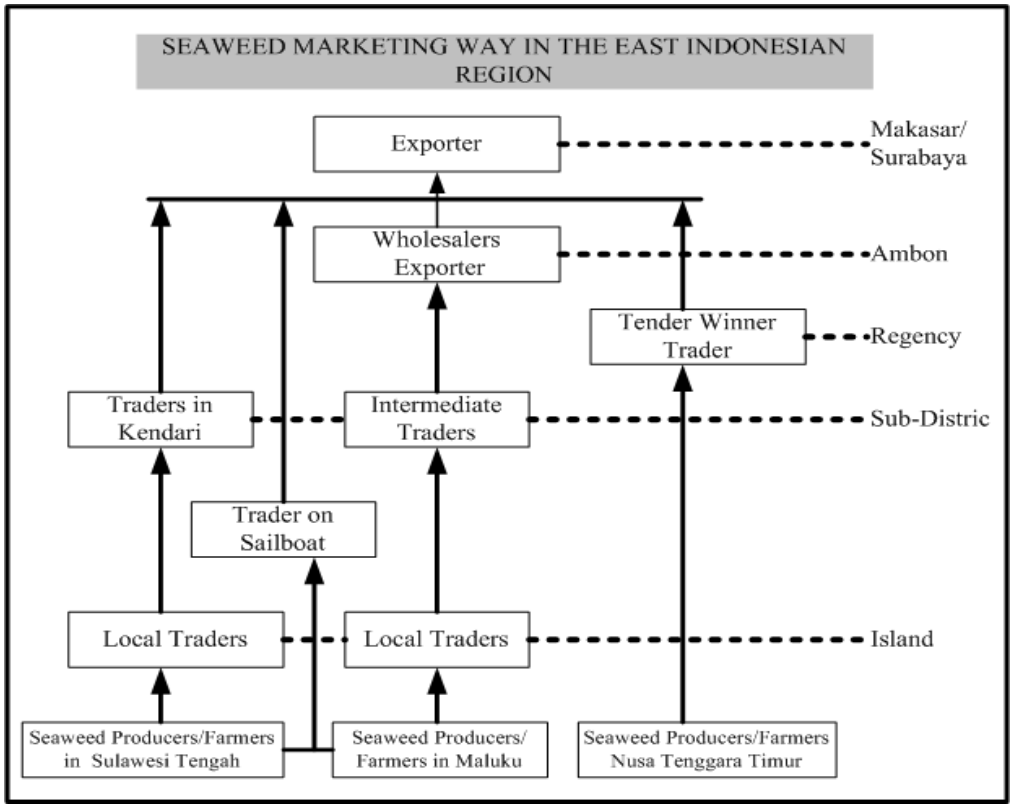

Figure 1 Seaweed Distribution Chain Path in Eastern Indonesia

2 Literature review

The development of seaweed cultivation is an alternative to empowering coastal communities, which has advantages in terms of a) the products produced have various uses; b) efficiency in land use with a high level of productivity; c) business units can be determined according to capital capacity by using simple technology; and d) easy to monitor because the cultivation container is relatively limited and protected from predators and easy to harvest [7]. Seaweed cultivation has a vital role in efforts to increase fishery production to meet food and nutritional needs and meet domestic and foreign market needs, expand job opportunities, increase the income and welfare of cultivators and maintain the preservation of aquatic biological resources. Seaweed has bright prospects as a trading commodity that has the opportunity to be developed in Indonesian waters [8].

Maluku Province is one of the largest seaweed producers in Indonesia. The distribution area for seaweed cultivation in Maluku province is spread over six regencies: Seram Bagian Barat (SBB) Regency, Maluku Tengah Regency, Maluku Tenggara Regency, Maluku Barat Daya (MBD) Regency, Seram Bagian Timur (SBT) Regency, and the Kepulauan Aru Regency. Seaweed production in 2020 in Maluku Province is 71,928.65 tons with a production value of Rp. 224,634,529,000, - and the planting frequency is six times a year [1]. This result is still far from what is expected, considering the enormous potential of the seaweed cultivation business. Based on regional characteristics and availability of resources, the centers for developing seaweed cultivation areas in Maluku Province are: 1. Seram Bagian Barat (SBB): West Seram; 2. Kepuluan Aru: Wamar Island; 3. Maluku Tenggara: Kei Kecil; 4. Maluku Tengah: Tuhaha Bay (Saparua Island) and Nusalaut Island; 5. Maluku Barat Daya (MBD): Saumlaki.

Although seaweed cultivation is relatively easy, the process still requires operational costs. Most farmers depend on business capital per family, so the number of units of seaweed cultivated is also different; limited capital is a common obstacle felt by seaweed farmers [9]. This fee is generally used to buy ropes, buoys, seedling ropes, wooden stakes, labor costs for seedling, buying seeds, diesel fuel costs, transportation costs for rent (for those who do not have a canoe or boat, especially if the cultivation area is a bit far from where they live). To reduce costs, some cultivators have finally asked for assistance in providing seeds to middlemen or collectors, which will later be deducted during harvest transactions. Due to the high cost of production, the subsequent impact is that the exchange rate in the agricultural and plantation sectors is

low, especially when compared to the development of prices for other basic needs of the community [10].

Wholesalers control the price of seaweed, in this case, the markets in Makassar and Surabaya. Meanwhile, in terms of selling their harvests (both wet and dry), many farmers complain because they do not have a strong bargaining position, especially in determining the selling price of seaweed. The interaction between farmers and cultivators with markets on the mainland is still weak, so until now, market access has only been collected by the same people. Based on these conditions, middlemen tend to manipulate prices according to their wishes and carry out monopolies. One of the reasons for the decline in seaweed sales is the price distortion at the collector level, where the price is determined by the buyer or middlemen [6,11].

In general, the bargaining positions of farmers with middlemen or debt bondage are relatively low, so even though they are primary producers, in the structure of the fishery commodity trading chain, their position is generally weak [10]. Due to their lack of access to markets and the constraints of existing transportation infrastructure, local farmers are often powerless when they bargain about the selling price of the commodities they produce.

Production until now is still in the form of raw materials, where farmers directly sell their harvests in wet form or sell dry crops. Because it is only raw materials, the price of this commodity is controlled by buyers in the Makassar or Surabaya markets. The condition of the low price set by buyers in Surabaya will increasingly "suffocate" farmers because collectors or middlemen will also manipulate the price. This is what causes seaweed farmers to stop cultivating, even en masse. This is in line with [6] findings that the saturation of the selling price of seaweed causes not all people to want to become seaweed farmers.

Several factors have caused the agricultural sector in the archipelago to have not been able to develop optimally, in addition to the unavailability of production facilities in the local market, also because local farming communities generally do not understand properly how to cultivate correctly, the seeds and superior varieties offered are not by the preferences of the farming families [12]. In general, seaweed farmers in Indonesia experience a lack of knowledge, causing a lack of innovation in managing crop yields by market demand [13]. Meanwhile, the processing process has not been supported by adequate technology and facilities because the existing industry is home.

The decline in seaweed sales was due to erratic seasonal/weather factors, water pollution, disease-infected seaweed, and the presence of seaweed predators [6,14]. This also occurs in seaweed cultivation in Seram Bagian Barat (SBB) Regency, where the cultivation conditions have begun to decline. Cultivated seaweed suffers from “fall off” disease. According to farmers, this disease causes crop yields to decrease by up to 50%, and in some cases, there are total crop failures.

Many previous studies on seaweed, one of them by [15], analysed the feasibility of seaweed cultivation in the Seram Bagian Barat (SBB) regency. The value obtained by IRR is 97.5%, higher than the commercial bank interest rate prevailing at the time of the study, which is 18%. The IRR is greater than the commercial bank interest, indicating that the seaweed cultivation business can develop. This is also supported by several similar studies conducted in southern Konawe and Pulau Laut Kotabaru, Indonesia [16,17]. [3] Tries to see the contribution of technology components (technoware, humanware, infoware and orgaware) to increase seaweed productivity in the Seram Bagian Barat (SBB) Regency. This study indicates that the technoware component provides the highest contribution to the productivity of seaweed cultivation. [18] Conducted risk identification, risk assessment, and risk mitigation of the seaweed supply chain in Indonesia using Multi-Criteria Decision Analysis (MCDA) by proposing alternative risk prevention/mitigation strategies, the Fuzzy Failure Mode and Effect Analysis method. (Fuzzy -FMEA) is also used to identify supply chain risks for seaweed cultivation in Sabah Malaysia [19]. In addition, [20] mapping a strategy for developing seaweed cultivation using SWOT analysis, shows that the priority for the weakness factor is the absence of financial institutions as providers of capital and the existence of a trade monopoly from middlemen, as well as fluctuating prices.

This study looks at one of the gaps or problems in the marketing and distribution of seaweed dominated by middlemen/broker/collector (called tengkulak) and is approached with a Multi-Criteria Decision Making (MCDM) method, namely the Analytical Hierarchy Process (AHP). However, this research has an element of novelty in producing priority strategies for post-harvest seaweed to shorten the seaweed distribution chain, which will impact the performance of the seaweed supply chain in the future.

3 Methodology

Research methodology, in principle, is a method or technique that is arranged regularly and systematically for problem-solving in achieving the desired goal [21]. This study discusses the selection of the best strategy that becomes a priority for preventing the dominance of middlemen in seaweed cultivation in the Seram Bagian Barat (SBB) Regency, which is approached by a Multi-Criteria Decision Making (MCDM) method, namely the Analytical Hierarchy Process (AHP). The following are several stages in this research referring to the steps and basic principles of AHP:

1. The first stage is to determine the objectives, criteria, sub-criteria, and strategies through literature studies, brainstorming, and interviews with experts such as the Industry and Trade Office, Field instructor of Marine and Fishery Office, Processing and Marketing Division of the Maluku Province Marine and Fisheries Office, academics, farmers or seaweed cultivators which will then be used in the preparation of the assessment questionnaire.

2. The next stage is decomposition, namely constructing the problem into a hierarchical structure, namely level 1: Goals; level 2: criteria; level 3: sub-criteria; level 4: rating scale; level 5: strategies, as shown in Figure 2 below:

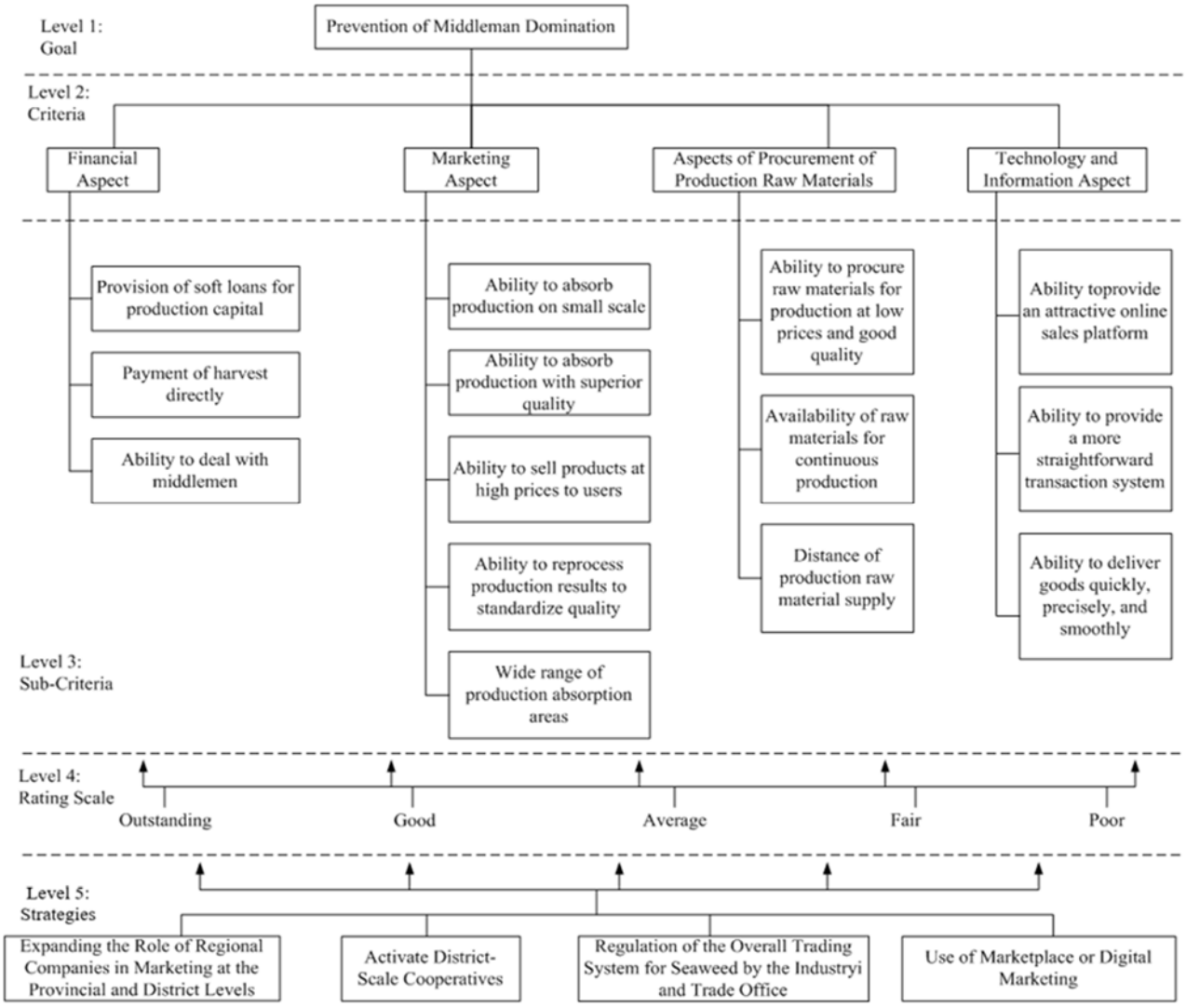

Figure 2 The hierarchical structure of strategy selection of middlemen prevention

3. After the hierarchical structure and questionnaire were developed, the next stage was the assessment of pairwise comparisons between criteria and sub-criteria by respondents, which was then transformed into a paired comparison matrix for numerical analysis. The numerical value for all comparisons is obtained from a comparison scale from 1 - 9, which Saaty has set, as in table 1 below [22]. The results of the questionnaire recap by each respondent were collected, combined, and processed using the geometric mean approach at each criterion and sub-criteria level to obtain the corresponding consensus pairwise comparison judgment matrices [23-24].

Table 1 Pairwise comparison rating scale

Scale	Pairwise	Definition
1	1	Equal Importance
3	$1/3$	Moderately more important
5	$1/5$	Strongly more important
7	$1/7$	Very strongly more important
9	$1/9$	Extremely more important
2,4,6,8	$1/2$, $1/4$, $1/6$, $1/8$,	Intermediate

4. Consistency test. In determining the weight of each criterion, it is necessary to test the consistency of preferences to find out whether there is a random element. Inconsistency may occur because humans have limitations in expressing their perceptions consistently, especially when comparing many criteria [25], [26]. The consistency index (CI) is calculated using Equation 1, where max is the largest unique eigenvalue n and is the size of the matrix.

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (1)$$

The inconsistency limit that Saaty has set is determined using the Consistency Ratio (CR) equation, which is the comparison of the Consistency Index (CI) with the Random Index (RI) value shown in equation 2. The assessment is said to be consistent if the CR value < 0.1

$$\boldsymbol{CR} = \frac{\boldsymbol{CI}}{\boldsymbol{RI}} \quad (2)$$

5. Determination of weighting criteria and ranking with five Liberatore Scales. Based on the pairwise comparison calculations obtained in the previous stage, the weights for the criteria and sub-criteria were calculated. After obtaining the weights of each criterion, then each criterion is entered into five Liberatore scales, which consist of Outstanding (O), Good (G), Average (A), Fair (F), and Poor (P), adjusted for assessment between strategies [27-29]. Table 2 below is the Pairwise comparison judgment matrix (PCJM) for the five-point rating scale.

Table 2 Pairwise comparison judgment matrix (PCJM) for five-point rating scale

	O	G	A	F	P
O	1	3	5	7	9
G	1/3	1	3	5	7
A	1/5	1/3	1	3	5
F	1/7	1/5	1/3	1	3
P	1/9	1/7	1/5	1/3	1

This matrix is then translated into the largest eigenvalue problem and the resulting priority weights of Outstanding = 0.513, Good = 0.261, Average = 0.129, Fair = 0.063 and Poor = 0.034 [29].

4 Result and discussion

4.1 Determination of strategy prevention for Middlemen

The problem of middlemen is no longer a new scourge among cultivators of agricultural products. So, choosing how to deal with middlemen is not an easy thing. Many efforts have been made by government, private and non-governmental organizations (NGOs) to tackle the problem of middlemen, but it is still tough to find success stories from these efforts. Because the success of seaweed cultivation involves quite a lot of cultivators' independence from middlemen, selecting methods to prevent these middlemen is very important.

The method used to select strategy methods for dealing with middlemen is AHP. This method is used because AHP can make the problem of selecting a middlemen prevention method more structured and able to cover various influential criteria. AHP also accommodates different weighting for each criterion and considers the level of consistency in the weighting.

In order to prevent the domination of the middlemen, it is necessary to formulate a strategy that can be applied to reduce the factors causing the strong dominance of the middlemen in the life of seaweed farmers. The strategy used in preventing the domination of middlemen is formulated from the results of a literature study and interviews with experts in the field of seaweed marketing. The strategies proposed are strategies that are considered to contribute to preventing the problem of middlemen domination.

The strategies are as follows:

1. Expanding the Role of Regional Companies in Marketing at the Provincial and District Levels. Regional-Owned Enterprises (BUMD) are business entities whose capital is partially/wholly owned by the regional government to provide services to the local community. The purpose of the BUMD itself is to serve the community's needs in the area and obtain profits that will be used for development in the area. So far, the business entities that we often encounter are the Regional Drinking Water Company (PDAM). PDAM itself also always assists communities in remote areas through capital assistance. Likewise with banking companies such as the Maluku Regional Development Bank or BPDM. The role of banking for the community is not only in cities but also in remote areas. This is through capital assistance for people who want to build a business. The role of regional companies to assist the community in developing businesses engaged in fishery products is still very minimal.

   For this reason, it is necessary to expand the role of regional companies in encouraging and assisting the community in developing their businesses. For example, the seaweed cultivation business is a trend in the industrial sector. This is to overcome the problems in farmers related to seaweed marketing. So that later it is hoped that the role of regional companies can reduce

the role of middlemen in marketing seaweed so that the seaweed marketing chain becomes short and the lives of seaweed farming communities become prosperous [2,30]. For this reason, the expansion of the role of regional companies is significant for the government to follow up.

2. Activate District-Scale Cooperatives. A fishery cooperative specializing in handling seaweed was developed as an effective forum for fighting for the interests of seaweed farmers. Through this cooperative, it is hoped that countervailing power will be created against various business climates that have been detrimental to seaweed farmers. In addition, cooperatives are also expected to develop more profitable input and output markets, improve production and marketing efficiency, better risk management, ensure business continuity, and increase the income of seaweed farmers [31].
   The model for developing cooperation in the development of seaweed farmers involving cooperatives is as follows:

a. Partnership Cooperation Pattern. Partnerships between farmers/farmer groups/cooperatives and partner companies can be made according to two patterns, namely:

- Farmers who are farmer groups enter into direct cooperation agreements with Marine and Fisheries/Exporter Processing Companies.
  The scheme of this partnership pattern can be seen in Figure 3 below:

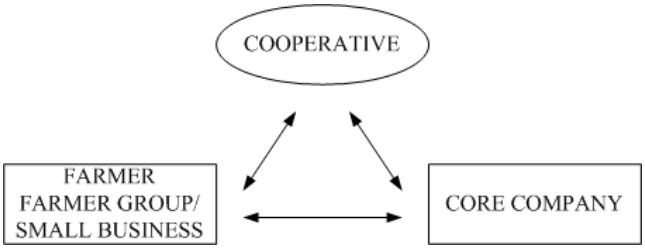

Figure 3 Partnership Pattern 1

With this form of cooperation, lending to plasma farmers is carried out with the cooperative position as Channeling Agent, and farmer groups directly handle its management. While the Partner Company must provide the problem of coaching.

- Farmers who are members of farmer groups, through their cooperatives, agree with the cooperative (representing its members) and marine and fishery/processing/exporter companies.
  The scheme of this partnership pattern can be seen in Figure 4 below:

Figure 4 Partnership Pattern 2

In this form of cooperation, lending to plasma farmers is carried out with the cooperative position as Executing Agent. The problem of technical development of plant cultivation/business management, if the Partner Company cannot implement it, will be the responsibility of the cooperative. The mechanism of the Integrated Partnership Project can be seen in Figure 5 below:

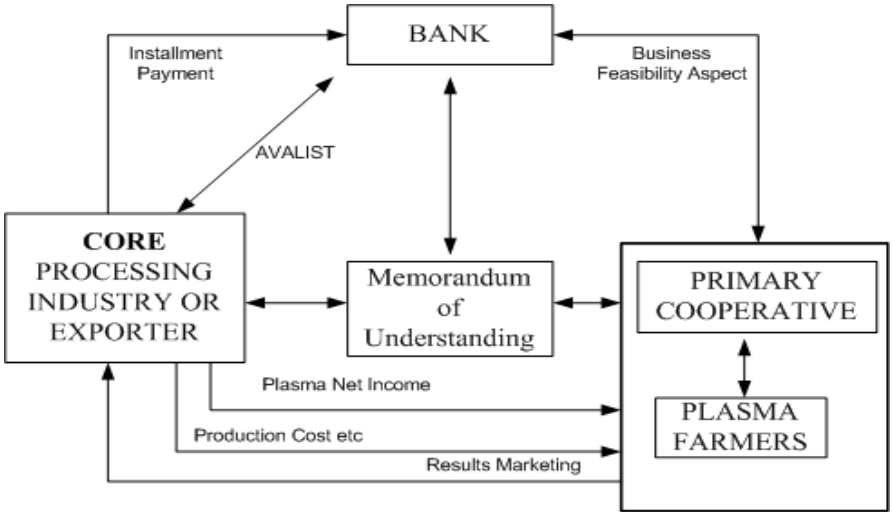

Figure 5 Integrated Partnership Project Mechanism

The implementing bank will assess the feasibility of the business by the technical bank principles. If the project is feasible to develop, it is necessary to make a memorandum of understanding (Memorandum of Understanding = MoU) that binds each partnering party's rights and obligations (core, Plasma/Cooperative, and Bank). By the memorandum of agreement, under the authorization of the cooperative or plasma, bank credit can be transferred from the cooperative/plasma account to the core account to be further distributed to plasma in the form of production facilities, physical work funds, and others. Thus, plasma will not receive cash from banks but will receive production facilities whose distribution can be through the nucleus or cooperatives. Plasma farmers carry out the production process. The results of the plasma plantations are sold to the nucleus at a price agreed in the MoU. The core company will deduct a portion of the plasma sales proceeds to be handed over to the bank as loan installments, and the rest returned to the farmers as net income.

b. Cooperatives as an Independent Company. The cooperative will provide the production equipment needed for seaweed cultivation, so it is only a matter of installation and planting. In addition, the cooperative will also provide loans for the purchase of seeds and daily needs. All of this will be calculated with the harvest results later, where farmers are only allowed to sell their produce to the cooperative at the prevailing local market price.

3. Regulation of the Overall Trading System for Seaweed by the Industry and Trade Office. The economic marketing of seaweed cultivation lies in the problem of profit and loss resulting from the business. This mainly depends on the high production costs incurred, the amount of production per business unit, and the sale of cultivated products. Until now, the marketing pattern of seaweed products in Indonesia from producers (producers) to consumers is still very long and is determined by middlemen. The length of the marketing chain and the lack of uniformity in prices in an area make the acceptance of seaweed producers very low. As the most experienced government agency in regulating the intricacies of the marketing sector, the Industry and Trade Office can play an active role in establishing an institution whose functions and objectives resemble the role of regional companies in regulating the entire trade chain but also concurrently the role of cooperatives in providing financial assistance to improve welfare fishermen [2,31].

4. Use of Marketplace or Digital Marketing. The marketplace is a solution created from the rapid development of information technology and the internet attacking the trading industry. In this marketplace, every business actor can display their products for sale without the hassle of building a system. [32] State that the existence of a marketplace is very beneficial for business actors who will market their products, especially for seaweed farmers who will market seaweed products. The marketplace can make it easier for seaweed farmers to carry out their operations. With the virtual market, marketing can be done directly to end consumers so that the distribution chain becomes short, and business actors only need to provide complete information about the products they sell in the marketplace, such as product information, prices, shipping, and others.

The criteria and sub-criteria used in the decision model on dealing with middlemen were obtained through brainstorming and interviews with experts and then described in a hierarchical structure (see Figure 2). The following are criteria and sub-criteria for preventing middlemen domination:

1. Financial Aspect: this is an aspect related to the Ability to provide production funds for seaweed farmers, which has been the key to strengthening the existence of middlemen. The sub-criteria from this financial aspect are:

a. Provision of soft loans for production capital. Most of the seaweed farmers in Indonesia have very low-income levels; therefore, to start a seaweed cultivation business, they need a soft loan with a payment scheme by cutting the purchase price of seaweed production.
b. Payment of harvest directly. In general, the carrageenan industry, as the final consumer of dried seaweed products, pays in demand deposits (usually they can be disbursed after two weeks – 1 month). This payment pattern is tricky for seaweed farmers because they need cash payments to pay their consumption debts and replant seaweed.
c. Ability to deal with middlemen. In the interval before seaweed can be harvested and make money, seaweed farmers meet their daily needs by first taking debts to the stalls to buy necessities. The debt is repaid after the seaweed is harvested and produces fruit. It is in this section that the middlemen generally play their role. If there is a disaster that can cause the seaweed harvest to fail, the seaweed farmers will immediately go to the middlemen to get loans to continue to pay their consumption debts. Therefore, by providing consumer credit funds, the role of middlemen can be minimized.

2. Marketing Aspect: relates to the competence to deal with the problems of seaweed farmers in selling their products (dried seaweed). The sub-criteria of this marketing aspect are:

a. Ability to absorb production on a small scale. Seaweed farmers have obstacles to supply directly to the carrageenan industry because the production capacity is much smaller than the supply expected by the carrageenan industry to maintain the continuity of the production process. Therefore, it is hoped that the

production of seaweed farmers on various scales can be absorbed without any problems.

b. Ability to absorb production with superior quality. Because seaweed farmers do not have sophisticated tools to control the water content of the dried seaweed they produce, often the quality of fisherman's products varies because they only rely on intuition. This is what mainly causes the production of seaweed farmers to be rejected by the carrageenan industry
c. Ability to sell products at high prices to users. It is hoped that the strategy to middlemen will be able to negotiate with the industry and significantly increase the price of dried seaweed because it has a better bargaining position than individual farmers.
d. Ability to reprocess production results to standardize quality. To increase the bargaining position so that the carrageenan industry is willing to absorb seaweed products, further processing is needed so that the quality of the various seaweed productions can meet the standard.
e. Wide range of production absorption areas. Infrastructure in coastal areas is very inadequate, but it is hoped that all dried seaweed produced by farmers in remote areas can still be absorbed as a whole.

3. Aspects of Procurement of Production Raw Materials: includes the ability to provide all needs for seaweed farmers when they carry out production activities or during the production period. The sub-criteria from this aspect of the procurement of raw materials for production are:

a. Ability to procure raw materials for production at low prices and good quality. Sometimes seaweed farmers are tricked by traders who sell tools and raw materials for seaweed production at stifling prices in credit schemes. It is hoped that farmers' needs for dry seaweed production can be met at a reasonable price in the future.
b. Availability of raw materials for continuous production. Often there is a shortage of tools and raw materials for seaweed production at a particular time, so seaweed farmers both from a financial perspective and from a credibility perspective in the eyes of the carrageenan industry are not good.
c. Distance of production raw material supply. It is hoped that the Availability of tools and raw materials for seaweed production can be available in areas with inadequate transportation facilities and infrastructure.

4. Information and Technology Aspect: the purpose of this aspect is to directly reach external parties such as suppliers and company consumers to make seaweed marketing more effective and efficient. The sub-criteria from the aspect of technology and information are:

a. Ability to provide an attractive online sales platform. It is hoped that it will be able to provide an online sales platform for consumer seaweed production to attract attention.
b. The Ability to provide a more straightforward transaction system. They have provided access for consumers to conduct transactions both electronically and physically.
c. Ability to deliver goods quickly, precisely, and smoothly. It is hoped that it will provide industrial support services in the delivery of seaweed needed by consumers today.

4.2 Processing with Liberatore scale

Based on the previous explanation above, the results of the questionnaire recap, which were divided into several respondents, were combined and processed using the geometric mean approach to obtain the corresponding consensus pairwise comparison judgment matrices [23], [24]. The results of the AHP data processing for the pairwise comparison assessment matrix of the problem of overcoming and preventing the dominance of middlemen in seaweed cultivation are shown in Table 3.

Each matrix is calculated with the maximum lambda value (λ_{max}), Index Consistency (CI), and normalization to obtain priority weights for each criterion and sub-criteria. Table 3 also shows the consistency ratio (CR) values of each Pairwise Comparison Judgment Matrix (PCJM) are all less than 0.1, which means that the answers from each respondent are consistent for the paired comparison matrix assessment [23,24].

The local weight is obtained from the average value of each sub-criteria to get the global weight value obtained from the product of the local weight value of the sub-criteria with the local weight value for each criterion shown in Table 4.

Furthermore, for the strategy weighting assessment, the method used is Liberatore with five priority weighting scales, namely Outstanding = 0.513, Good = 0.261, Average = 0.129, Fair = 0.063 and Poor = 0.034. This assessment is carried out based on 14 sub-criteria against existing strategies. Table 5 shows the recapitulation results of score calculations for each strategy to prevent middlemen domination in seaweed cultivation.

Based on the final weight calculation results for each of the strategies in table 5, the strategy "using the Marketplace or doing digital marketing" obtained the highest weight of 0.483. Furthermore, the strategy "Expanding the Role of Regional Companies in Marketing at the Provincial and Regency Levels"(0.241), the strategy "Activating Cooperatives on a District Scale" (0.224), and the strategy "The Department of Industry and Trade Regulate the Overall Chain of Commerce" (0.036). Therefore, it can be said that the strategy of "using the Marketplace or doing digital marketing" is the best in overcoming the problem of middlemen's dominance in the seaweed cultivation business. This is in line with the start of socialization and online marketing training for seaweed farmers and Small and Medium Enterprises (SMEs) scattered in the area by utilizing several existing Marketplaces such as Tokopedia, Bukalapak, Shopee, Lazada, and others. Not only that, but the government can also prepare a policy to expand the role

of local companies in buying post-harvest seaweed and activate district-scale cooperatives in helping farmers by providing access to borrowing capital to start production as proposed [2,6] so that the price game done by middlemen can be eliminated.

Table 3 Pairwise comparison assessment matrix of middlemen domination prevention problems

Goal	FA	MA	APPRM	ITA	**Priority**
Financial Aspect (AF)	1.0	1.0	4.6	2.7	0.409
Marketing Aspect (MA)	1.0	1.0	3.1	1.0	0.296
Aspects of Procurement of Production Raw Materials (APPRM)	0.2	0.3	1.0	1.0	0.115
Information and Technology Aspect (ITA)	0.4	1.0	1.0	1.0	0.181
		λ_{max} = 4.174	CI = 0.058	CR =	0.064

Financial Aspect	PSLPC	PHD	ADM	**Priority**
Provision of Soft Loans for Production Capital (PSLPC)	1.0	5.1	6.6	0.715
Payment of Harvest Directly (PHD)	0.2	1.0	3.3	0.201
Ability to Deal with Middlemen (ADM)	0.2	0.3	1.0	0.084
		λ_{max} = 3.100	CI = 0.050	CR =	0.086

Marketing Aspect	AAPSS	AAPSQ	ASPHPU	ARPRSQ	WRPAA	**Priority**
Ability to Absorb Production on a Small Scale (AAPSS)	1.0	1.9	1.6	2.0	2.6	0.299
Ability to Absorb Production with Superior Quality (AAPSQ)	0.5	1.0	2.7	2.6	2.5	0.274
Ability to Sell Products at High Prices to Users (ASPHPU)	0.6	0.4	1.0	3.4	3.5	0.225
Ability to Reprocess Production Results to Standardize Quality (ARPRSQ)	0.5	0.4	0.3	1.0	2.2	0.120
Wide Range of Production Absorption Areas (WRPAA)	0.4	0.4	0.3	0.5	1.0	0.082
		λ_{max} = 5.372		CI = 0.093	CR =	0.083

Aspects of Procurement of Production Raw Materials	APRMPLPGQ	ARMCP	DPRMS	**Priority**
Ability to Procure Raw Materials for Production at Low Prices and Good Quality (APRMPLPGQ)	1.0	3.2	4.3	0.622
Availability of Raw Materials for Continuous Production (ARMCP)	0.3	1.0	3.1	0.264
Distance of Production Raw Material Supply (DPRMS)	0.2	0.3	1.0	0.114
		λ_{max} = 3.079	CI = 0.039	CR =	0.068

Information and Technology Aspect	APAOSP	APMSTS	ADGQPS	**Priority**
Ability to Provide an Attractive Online Sales Platform (APAOSP)	1.0	3.3	6.7	0.652
Ability to Provide a More Straightforward Transaction System (APMSTS)	0.3	1.0	4.8	0.271
Ability to Deliver Goods Quickly, Precisely, and Smoothly (ADGQPS)	0.1	0.2	1.0	0.076
		λ_{max} = 3.084	CI = 0.042	CR =	0.072

Table 4 Composite priority weights for critical success factors

Criteria	Local weights	Subcriteria	Local weights	Global weights
Financial Aspect (AF)	0.409	Provision of Soft Loans for Production Capital (PSLPC)	0.715	0.292
		Payment of Harvest Directly (PHD)	0.201	0.082
		Ability to Deal with Middlemen (ADM)	0.084	0.034
Marketing Aspect (MA)	0.296	Ability to Absorb Production on a Small Scale (AAPSS)	0.299	0.088
		Ability to Absorb Production with Superior Quality (AAPSQ)	0.274	0.081
		Ability to Sell Products at High Prices to Users (ASPHPU)	0.225	0.066
		Ability to Reprocess Production Results to Standardize Quality (ARPRSQ)	0.120	0.036
		Wide Range of Production Absorption Areas (WRPAA)	0.082	0.024
Aspects of Procurement of Production Raw Materials (APPRM)	0.115	Ability to Procure Raw Materials for Production at Low Prices and Good Quality (APRMPLPGQ)	0.622	0.071
		Availability of Raw Materials for Continuous Production (ARMCP)	0.264	0.030
		Distance of Production Raw Material Supply (DPRMS)	0.114	0.013
Information and Technology Aspect (ITA)	0.181	Ability to Provide an Attractive Online Sales Platform (APAOSP)	0.652	0.118
		Ability to Provide a More Straightforward Transaction System (APMSTS)	0.271	0.049
		Ability to Deliver Goods Quickly, Precisely, and Smoothly (ADGQPS)	0.076	0.014
			Total :	1

Table 5 Recapitulation of Weight Calculation Strategies for the prevention of middlemen

Strategic criteria issues	Global Weights	Expanding the Role of Regional Companies in Marketing at the Provincial and District Levels			Activate District-Scale Cooperatives			Regulation of the Overall Trading System for Seaweed by the Industry and Trade Office			Use of Marketplace or Digital Marketing		
Critical Succses Factors (Subcriteria)		Rating	Score	×GW	Rating	Score	×GW	Rating	Score	×GW	Rating	Score	×GW
Financial Aspect													
Provision of Soft Loans for Production Capital (PSLPC)	0.292	A	0.129	0.038	A	0.129	0.038	P	0.034	0.010	O	0.513	0.150
Payment of Harvest Directly (PHD)	0.082	G	0.261	0.021	G	0.261	0.021	P	0.034	0.003	O	0.513	0.042
Ability to Deal with Middlemen (ADM)	0.034	G	0.261	0.009	G	0.261	0.009	P	0.034	0.001	O	0.513	0.018
Marketing Aspect													
Ability to Absorb Production on a Small Scale (AAPSS)	0.088	A	0.129	0.011	A	0.129	0.011	P	0.034	0.003	O	0.513	0.045
Ability to Absorb Production with Superior Quality (AAPSQ)	0.081	G	0.261	0.021	G	0.261	0.021	P	0.034	0.003	O	0.513	0.042
Ability to Sell Products at High Prices to Users (ASPHPU)	0.066	G	0.261	0.017	G	0.261	0.017	P	0.034	0.002	G	0.261	0.017
Ability to Reprocess Production Results to Standardize Quality (ARPRSQ)	0.036	O	0.513	0.018	G	0.261	0.009	P	0.034	0.001	G	0.261	0.009
Wide Range of Production Absorption Areas (WRPAA)	0.024	G	0.261	0.006	G	0.261	0.006	P	0.034	0.001	O	0.513	0.012
Aspects of Procurement of Production Raw Materials													
Ability to Procure Raw Materials for Production at Low Prices and Good Quality (APRMPLPGQ)	0.071	O	0.513	0.037	G	0.261	0.019	P	0.034	0.002	A	0.129	0.009
Availability of Raw Materials for Continuous Production (ARMCP)	0.030	G	0.261	0.008	G	0.261	0.008	P	0.034	0.001	O	0.513	0.016
Distance of Production Raw Material Supply (DPRMS)	0.013	G	0.261	0.003	G	0.261	0.003	P	0.034	0.000	A	0.129	0.002
Information and Technology Aspect													
Ability to Provide an Attractive Online Sales Platform (APAOSP)	0.118	G	0.261	0.031	G	0.261	0.031	P	0.034	0.004	O	0.513	0.060
Ability to Provide a More Straightforward Transaction System (APMSTS)	0.049	G	0.261	0.013	G	0.261	0.013	P	0.034	0.002	O	0.513	0.025
Ability to Deliver Goods Quickly, Precisely, and Smoothly (ADGQPS)	0.014	O	0.513	0.007	G	0.261	0.004	P	0.034	0.000	O	0.513	0.007
Total Scores				0.241			0.211			0.034			**0.455**
Renormalized Scores				0.256			0.224			0.036			**0.483**

5 Conclusions

This study assesses various strategies in preventing the role of middlemen in seaweed cultivation in Seram Bagian Barat (SBB) Regency, Maluku Province, using the AHP technique approach. The main obstacle faced by seaweed cultivators in developing their business is the dominance of middlemen who have roots in seaweed cultivators, so this requires serious handling from various related parties such as the cultivators themselves, the government, and other relevant agencies to formulate strategies for dealing with middlemen.

The results of the AHP calculation show that the strategy chosen is the strategy "Using the Marketplace or doing digital marketing," getting the highest weight of 0.483. The strategy "Expanding the Role of Regional Companies in Marketing at the Provincial and District Levels"(0.241), the strategy "Activating Cooperatives by District scale" (0.224), and the strategy "Department of Industry and Trade Regulate the Overall Chain of Commerce" (0.036). Strategies to opening a Market Place or doing digital marketing are expected to break the chain or prevent the domination of middlemen in the seaweed cultivation business. This strategy is also easy to use by farmers or cultivators because it utilizes several marketplaces that are already available without having to build the system. Also, the use of this marketplace has been supported by internet network infrastructure that has reached these areas.

This research, of course, has limitations with the subjective AHP model. However, this research can be developed by integrating several MCDM methods such as Technique For Others Reference by Similarity to Ideal Solution (TOPSIS) and Data Envelopment Analysis (DEA) to get more objective results. In the future, this research can be continued by using the Supply Chain Operations Reference (SCOR) model to measure the performance of the seaweed supply chain in Seram Bagian Barat Regency. It can then be combined with the House of Risk method for managing seaweed supply chain risks so that the government can take appropriate and strategic steps to improve the welfare of coastal communities, especially seaweed farmers.

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MODIFIED PROMETHEE V METHOD FOR SUPPLIER PORTFOLIO SELECTION
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MODIFIED PROMETHEE V METHOD FOR SUPPLIER PORTFOLIO SELECTION

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Keywords: PROMETHEE V, mixed integer programming, supplier portfolio, flexible constraint.
Abstract: This paper focuses on the problem of supplier portfolio selection where a company has to choose the best possible set of suppliers with respect to various constraints. An intuitive heuristic can suggest to use any of the methods for suppliers ranking and then to put the first one into the portfolio. If some required constraint is not met, then the second supplier according to the ranking is added, and so on, until all the constraints are satisfied. However, such approach can result in a non-optimal decision. The constraints can cause that a combination of the alternatives with lower rankings can be better, than some higher-ranked alternative from the perspective of feasibility. To build the optimization model, the authors of this paper use the PROMETHEE V method: a popular combination of multi-criteria decision making method PROMETHEE and mixed integer programming. However, it is shown that the original PROMETHEE V method, namely the logic under which an objective function is set, is not suitable here and leads to discrimination of suppliers with worse ranking. Therefore, a modification, which brings more reasonable results, is proposed in this paper. A numerical example is used to show the suitability of the proposed approach and compare the results with the original algorithm and also with one prior modification introduced by by other authors in the past. The analysis is further supported by a thorough sensitivity analysis using flexible and parametric programming.

1 Introduction

Suppliers and their quality play a vital role in competitiveness of each production company. Potential troubles with suppliers, like delayed delivery, poor quality of products, difficult communication, or overpriced goods, can be the source of the bottleneck with ominous consequences. Therefore, managers should be very careful to select the most suitable suppliers. In order to do so, many quantitative tools are available to make their selection easier. This problem is a common topic of multi-attribute decision making (MADM). It would be almost impossible to find a MADM method, which has not been used yet to evaluate suppliers. Let us mention at least the methods, which are currently very popular in quantitative support of decision making: Analytic Hierarchy Process (AHP) [1], Analytic Network Process (ANP) [2], TOPSIS [3], ELECTRE [4], PROMETHEE [5]. But, all these studies provide the ranking of suppliers, which is sufficient when the best supplier is identified, or, when companies measure the performance of their current suppliers. However, for many reasons, companies usually do not have only one supplier for all their inputs (either they hedge against risk, or simply because of the availability of the goods). And then, several dependencies and synergistic effects can occur. In this paper, these dependencies and effects will be taken into consideration to identify the best suitable combination of suppliers for a company. The aim is to find the best feasible portfolio of suppliers based on a given set of criteria.

Despite the problem of supplier portfolio selection is by far not as frequent as the ranking problem mentioned above, several studies have also been published. Namely, the authors of [6] have established the model based on the combination of ANP and Data Envelopment Analysis (DEA), and the authors of [7] have presented the model based on genetic algorithms and mathematical programming. Despite these models are very valuable, in our opinion they are very difficult to understand for practitioners, which can limit their use for real-life problems. The model presented in this paper is based on the PROMETHEE method established by [8] and its extension for the portfolio selection presented by [9] (so called PROMETHEE V). The PROMETHEE method is easy to use, since its algorithm is computationally easy and also tractable, see [10], and it provides the ranking of alternatives. Based on this ranking, the portfolio is found using the mixed integer programming (MIP) within the PROMETHEE V method. In this paper, the suitability of the PROMETHEE V method to solve the supplier portfolio selection problem is shown.

As mentioned by [11] and [12], the original PROMETHEE V method suffers from a severe drawback.

Namely, the alternatives with negative values in the PROMETHEE ranking (negative net flows, see Section 2) are discriminated. The authors of [11] have proposed a way how to eliminate this discrimination. However, the proposed method brings undesired biases in favour of large portfolios, see the proof by [13]. The authors of [12] have proposed another solution how to solve the drawback of PROMETHEE V based on the so called c optimal portfolios where the optimal portfolios for a fixed number of selected alternatives c are found. The new model is built on both proposed approaches, i.e. [11] and [12]. The original PROMETHEE V model is transformed according to [1] and explore the c-optimal portfolio. To avoid the biases in favour of large portfolio (like in the original proposal by [11]), the optimisation model is further modified. In the original PROMETHEE V and all its extensions mentioned above, the suitability of a portfolio is determined by the alternatives in this portfolio. To return to the case of supplier portfolio selection, each portfolio of suppliers is evaluated according to the suppliers involved in the portfolio. This is also the reason why the approach by [11] leads to the large portfolio involving all possible suppliers (if some further constraint does not make such solution infeasible), regardless of the supplied quantity. In our opinion, the utility for the supplied company is not generated by suppliers themselves, but through the supplied goods. Therefore, the built model considers that the optimal portfolio is evaluated not only according to the involved suppliers, but the supplied quantity too. In other words, it is supposed that if a supplier delivers 1,000 pieces of some product, or only a single piece, the generated utility is greater in the former case.

This paper brings two main contributions. First, the suitability of the PROMETHEE V method to solve the supplier portfolio selection problem due to its easy and tractable algorithm is demonstrated, and typical segmentation constraints for this problem are identified (the portfolio is constrained by the total budget, demand for products, availability of products at suppliers, size of the portfolio). Second, a new modification of the original PROMETHEE V method [9] is introduced, which is more suitable for the solved problem. On the other hand, it is worth noting that the proposed modification is established for the given application field. Its suitability for other areas must be assessed by a user for each potential application individually.

The paper includes a numerical example, which is solved using the original and modified PROMETHEE V method. Furthermore, a sensitivity analysis of the results for different levels of budget using the flexible and parametric programming is provided.

The rest of the paper is organised as follows. Section 2 recalls the methodology of the PROMETHEE rankings and PROMETHEE V for the portfolio selection. Section 3 presents the PROMETHEE V model for the supplier portfolio selection using both, the original and the new approach. Section 4 provides a numerical example, its results and the sensitivity analysis of the results. The last section, Section 5, concludes the paper and outlines possible directions for the further research.

2 PROMETHEE rankings and PROMETHEE portfolio selection

The family of the PROMETHEE methods belongs to outranking methods of multi-attribute decision making, i.e., its algorithms are based on special (outranking) preference relations. The basic PROMETHEE methods, established by [8], are used to get the rankings of alternatives based on a given (discrete) set of criteria (PROMETHEE I and PROMETHEE II). However, outputs from the PROMETHEE ranking can further be used to solve other decision making problems, like clustering the alternatives [14], efficiency evaluation [15], or portfolio selection [9]. Its variability is not the only advantage of PROMETHEE. It has become very popular mainly due to its very transparent computational procedure that is easy to understand, which is valuable also for practitioners. The popularity of the PROMETHEE method is proved by various fields of real-life applications published so far, see the review paper by [16].

In this section, a brief review of the PROMETHEE algorithms for ranking the alternatives and portfolio selection is provided. More detailed description can be found in [17].

In line with [18], the PROMETHEE ranking can be split into 4 following steps:

Step 1

Preference degrees $P_i(A_t, A_j) = P_i(v_{it} - v_{ij}) \in [0,1]$ are calculated for all pairs of alternatives A with respect to each criterion $i = 1,2, \dots, k$ using preference functions P_i (this function assigns a preference degree to each possible difference in performance values), where v_{it} stands for the performance of the t-th alternative with respect to the i-th criterion. The preference degree says, how much the decision-maker prefers an alternative with better performance in the given criterion to the one with worse performance.

Step 2

The preference degrees are aggregated to preference indices expressing, how much the decision-maker prefers one alternative to another. This is done using the sum product of preference degrees and weights w, see (1) and (2).

Step 3

The preference indices are aggregated to positive and negative flows ($\phi^+ \in [0,1], \phi^- \in [0,1]$) of each alternative, see (1) and (2). The positive flow of an alternative is a mean value of the preference indices comparing this alternative to the others (how much better is the alternative than the others). The other way around, the negative flow of an alternative is a mean value of the

preference indices comparing the remaining alternatives to the one under evaluation (how much worse is the alternative than the others).

Step 4
Due to the fact that the ranking using only the positive and negative flows (PROMETHEE I) provides only a partial ranking (a is preferred to b if $\phi^+(a) \geq \phi^+(b) \wedge \phi^-(a) \leq \phi^-(b)$, where at least one of both inequalities must be strict) these partial flows must be aggregated to the net flows $\phi \in [0,1]$, see (3). The PROMETHEE ranking based on the net flows is called PROMETHEE II and it provides a complete ordering.

The calculations of the described algorithm can be shortly written as follows:

$$\phi^+(A_t) = \frac{\sum_{j=1,j\neq t}^{s} \sum_{i=1}^{k} w_i \cdot P_i(v_{i,t} - v_{i,j})}{s-1} \quad (1)$$

$$\phi^-(A_t) = \frac{\sum_{j=1,j\neq t}^{s} \sum_{i=1}^{k} w_i \cdot P_i(v_{i,j} - v_{i,t})}{s-1} \quad (2)$$

$$\phi(A_t) = \phi^+(A_t) - \phi^-(A_t) \quad (3)$$

where w_i is the weight of the i-th criterion, s is the number of alternatives and k represents the number of criteria.

The authors of [8] have defined the general properties of a preference function. A decision-maker can choose any non-decreasing function P (the greater difference in performances, the greater (or equal) preference strength in favour of the better alternative) with $P(x) = 0$ for $x \leq 0$, with the domain of all real numbers ($x \in \mathbb{R}$) and the range $P(x) \in [0,1]$. In order to make the choice of preference functions simpler for decision-makers, the authors of [8] have proposed some predefined shapes. But, by far the most common shape is the linear one, which allows to consider too small differences in performance values negligible using the indifference threshold q, and, on the contrary, too big differences exceeding the preference threshold p are preferred absolutely and with the same strength, see Figure 1.

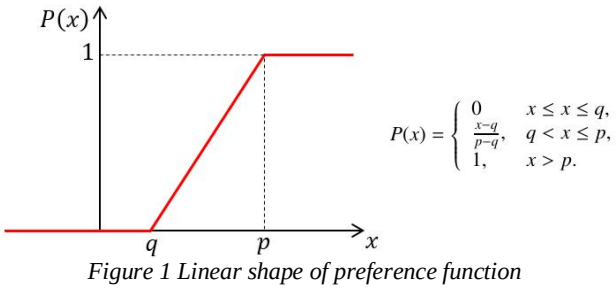

Figure 1 Linear shape of preference function

Multiple alternatives selection using PROMETHEE (PROMETHEE V), introduced by [9], is based on the PROMETHEE II ranking and its net flows ϕ. To find the optimal portfolio of alternatives, mathematical programming must be used. In comparison with the PROMETHEE II algorithm, optimisation models are more complicated to solve. But, the model to solve within the PROMETHEE V is still easily tractable and, in general, more simple than the models proposed by [6], or [7]. Let x_i be a binary decision variable denoting if the i-th alternative is involved in the portfolio, or not. Then, the optimisation model can be written as follows:

$$\begin{aligned} \max \quad & \boldsymbol{\phi}^{\mathrm{T}}\boldsymbol{x} \\ \text{s.t.} \quad & \mathbf{A}\boldsymbol{x} \leq \boldsymbol{b} \\ & \boldsymbol{x} \in \{0,1\}^s \end{aligned} \quad (4)$$

where the set of constraints with the coefficient matrix $\mathbf{A} \in \mathbb{R}^{n\times s}$ and the right-hand sides $\boldsymbol{b}$ are the segmentation constraints defining the feasibility of a solution. As mentioned in the introduction, dependencies and synergistic effects must be taken into account when selecting multiple alternatives. Each constraint in the model represents a restriction on the portfolio. For example, for a typical asset allocation problem, the constraints can be used to guarantee minimal expected profit and maximal acceptable risk.

3 PROMETHEE model for supplier portfolio selection

In this section, a general optimisation model of the supplier portfolio selection is provided in line with [18]. A company, which needs to deliver m product types by s potential suppliers, is considered. The company is limited by the following constraints:

- total delivery costs cannot exceed the budget b (5d);
- the demand $\boldsymbol{d}$ of the company must be completely satisfied (5b);
- the suppliers have available only limited quantities $\boldsymbol{r}$ of the required product types (5c);
- the portfolio can be restricted in size c (too many suppliers can cause organisational and bureaucratic troubles to the company, on the contrary, too few suppliers increase the risk), (5e).

$$\begin{aligned}
\max \quad & \sum_{j=1}^{s} \phi_j x_j && && \text{(a)} \\
\text{s.t.} \quad & \sum_{j=1}^{s} y_{ij} = d_i && i = 1,2,\dots,m, && \text{(b)} \\
& y_{ij} \leq r_{ij} && i = 1,2,\dots,m, j = 1,2,\dots,s, && \text{(c)} \\
& \sum_{i=1}^{m}\sum_{j=1}^{s} p_{ij} y_{ij} \leq b && && \text{(d)} \\
& \sum_{j=1}^{s} x_j = c && j = 1,2,\dots,s, && \text{(e)} \\
& \sum_{i=1}^{m} y_{ij} \leq M(1-a_j) && j = 1,2,\dots,s, && \text{(f)} \\
& a_j + x_j = 1 && j = 1,2,\dots,s, && \text{(g)} \\
& x_j \in \{0,1\} && j = 1,2,\dots,s, && \text{(h)} \\
& y_{ij} \geq 0 && i = 1,2,\dots,m, j = 1,2,\dots,s, && \text{(i)} \\
& a_j \in \{0,1\} && j = 1,2,\dots,s. && \text{(j)}
\end{aligned} \quad (5)$$

In the model (5), unlike the general formulation (4), new real variables y_{ij} are used, and they stand for the quantity of the i-th product delivered by the j-th supplier. Thus, the company decides on where to buy the products and how many products are delivered by each supplier. The constraints (5f) and (5g) result from the implication that if there is a supply from a supplier, this supplier is not involved in the portfolio, see Note 1 (M is a sufficiently great prohibitive constant, a_j is a binary dummy variable). The problem (5) is a model of mixed integer programming.

Note 1. The following implication is involved in model (5):

$$\sum_{i=1}^{m} y_{ij} > 0 \Rightarrow x_j = 1, \text{otherwise } x_j = 0,\ j = 1,2,\dots,s. \quad (6)$$

If there is some positive value of y_{ij} for any i, based on the constraint (5f), the corresponding a_j must be equal to zero and, according to (5g), x_j is equal to 1, i.e., the j-th supplier is selected.

The constraints in (5) are relevant for the vast majority of production companies. Each company can also add its individual specific constraints depending on conditions under which it operates. For instance, the following examples of such constraints can be considered:

- each product must be in stock at least at two suppliers for the sake of substitutability;
- total distance to the selected suppliers cannot exceed a given value;
- the shortest route between the selected suppliers cannot exceed a given value;
- delivery costs can also depend on load capacity utilisation (e.g., goods are transported to a customer by trucks and if a truck is not fully loaded, the delivery costs are greater (this also prevents from crumbling the supplied values).

As mentioned in the introduction, two drawbacks of PROMETHEE V make troubles to users.

First, if it is not necessary for the feasibility of a solution, alternatives with negative flows are always excluded from the portfolio because they would decrease the value of the objective function. But, it is not natural to take the zero value of ϕ as a critical threshold if to select the alternative or not. A negative value of ϕ indicates that the negative flow of the given alternative is less than its positive flow (i.e., the weaknesses overweights the strengths), see (3), but it does not necessarily mean, that the alternatives with negative net flows decrease the total utility of the company and vice versa. To face this drawback, the authors of [11] have come with the following modification of the objective function used in PROMETHEE V:

$$\max(\boldsymbol{\phi} + \boldsymbol{q})^{\mathrm{T}}\boldsymbol{x} \quad (7)$$

However, according to [13], the modification using (7) brings the opposite trouble to the original drawback. Namely, if it does not violate any constraint, the optimal portfolio would always include all the alternatives. For the case of (5), it means that each involved supplier would increase the total utility of the company, regardless of the supplied quantity. It can easily happen that it is optimal to deliver `almost zero' quantities from some suppliers, in order to artificially increase the objective function value. This is not desirable. One can admit that, the company can use the constraint (5e) to prevent this problem. However, in our opinion, the method should be applicable even without any additional constraint. Besides that, it is not always easy, or even possible, to set a suitable value for c in (5).

The second drawback is caused by the logic of the objective function as a whole and, in fact, it is the reason why the modification of the objective function proposed by [11] suffers from the troubles mentioned above. The objective function in (4) evaluates a solution according to which suppliers are chosen for the given portfolio. The logic behind is that if a supplier is selected, the evaluation profile of this supplier, including its advantages and disadvantages, is also reflected in 'quality' of its supplies. This idea is reasonable if the decision on a discrete alternative (e.g., a supplier) is not simultaneously accompanied with another decision on some quantitative property (e.g., if a university committee must select, which scientists will be awarded for their research, or municipal elections). However, in the presented supplier portfolio selection (5), the company decides not only on which suppliers are involved in the portfolio, but also on the delivered quantities y_{ij}. From the mathematical point of view, one cannot get the optimal values of variables, which are not included in the objective function. There is also a logical reason, why the function (5a) is not suitable for (5). This will be explained using a simple example. Let me consider the problem described by (5) with $m = 2$ and $s = 3$, i.e., the company requests 2 product types from 3 possible suppliers. Table 1 provides three different feasible solutions of the problem $S1, S2, S3$.

Table 1 Feasible solutions of the numerical example

Solution S_1	Supplier 1	Supplier 2	Supplier 3	Solution S_2	Supplier 1	Supplier 2	Supplier 3	Solution S_3	Supplier 1	Supplier 2	Supplier 3
Net flows:	0.1	0.5	0.9	Net flows:	0.1	0.5	0.9	Net flows:	0.1	0.5	0.9
Product A	20	20		**Product A**	40			**Product A**	10	30	
Product B		40	50	**Product B**		80	10	**Product B**			90

All three solutions bring the same value of the objective function equal to 1.5 using (a) in (5) because all three suppliers are always selected into the portfolio. But, intuitively, $S3$ is the best option and $S2$ is the worst one.

The reason is that, according to the PROMETHEE II ranking, Supplier 3 is the most preferable one (it has the greatest net flow); for example, it provides the best quality of the products and also the best service conditions. Hence, it is reasonable to prefer greater quantities delivered by high-ranked suppliers. Therefore, the authors propose to replace the original objective function (5a) with (8) for the problem described by the model (5).

$$\sum_{j=1}^{s} \phi_j y_{ij} \tag{8}$$

The use of (8) brings also other benefits. First, the modification (7) by [11] does not necessarily favor big portfolios. Second, if the company does not want to explicitly restrict the size of the portfolio, like in (5) using (e), the new optimisation model will not contain any binary variable, the constraints (5f) and (5g) will be excluded, and, thus, the problem will be a linear programming problem, which will be simpler, smaller and faster to solve. But, in this paper, all the constraints from (5) will be kept to provide the sensitivity analysis of the results for changing portfolio size:

$$\begin{aligned} \max \quad & \sum_{j=1}^{s} (\phi_j + q)\, y_{ij} \\ \text{s.t.} \quad & (5b) - (5j). \end{aligned} \tag{9}$$

where q is set in line with (7).

The objective function of the model (9) assigns 77, 53, 97 to three solutions in Fig. 2 $S1, S2, S3$, respectively. This result confirms the intuitive reflection above.

At the end of this section, it is worth emphasizing that the proposed modification is suitable for the considered decision making problem. But it cannot be automatically used for other problems without further analysis. As mentioned above, for some problems, the original PROMETHEE V model is more suitable. As well as it is possible that one can face a problem, for which none of the presented models makes sense, and which will require some completely unique approach.

4 Numerical example

In this section, a numerical example of the supplier portfolio selection is provided. Namely, the example presented by [19] is used. The original authors have used this example to demonstrate their DEA-based method to evaluate the suppliers. The original data to get the PROMETHEE rankings are used, and extended with necessary input data for the algorithms and models presented in Sections 2 and 3 similarly to [18], where the example has been solved using the original PROMETHEE V method.

The modeled company evaluates 18 potential suppliers S1-S18 using 5 quantitative criteria:

- Supply variety [number of provided product types] (maximizing);
- Quality [% of non-defect products] (maximizing);
- Distance [km] (minimizing);
- Delivery [% of products delivered in time] (maximizing);
- Price index [%] (minimizing).

The same importance is considered for all the criteria, i.e., each of them has a weight w equal to 0.2. All the criteria are treated using the linear shape of the preference function, see Figure 1. The performances of the suppliers in the given criteria, together with the thresholds for the preference functions, are displayed in Table 2.

Table 2 Performances of the suppliers and the threshold values p and q

	C1	C2	C3	C4	C5		C1	C2	C3	C4	C5
q	5	0	30	0	0	w	0.2	0.2	0.2	0.2	0.2
p	20	5	1000	20	11						
S1	2	100	249	90	100	S10	3	97.5	588	100	100
S2	13	99.8	643	80	100	S11	10	100	241	95	100
S3	3	100	714	90	100	S12	7	99.9	567	98	100
S4	3	100	1809	90	100	S13	19	100	567	90	100
S5	24	99.8	238	90	100	S14	12	91.9	967	90	100
S6	28	96.6	241	90	100	S15	33	100	635	95	80
S7	1	100	1404	85	100	S16	2	100	795	95	80
S8	24	100	984	97	100	S17	34	100	689	95	80
S9	11	99.9	641	90	100	S18	9	99.4	913	85	100

Using (1), (2), and (3), the PROMETHEE II ranking of the suppliers is calculated, see Table 3. In line with (7), the

transformation q is set to $\left|\min_j\{\phi_j\}\right| + 0.0001 = 0.3259$, without loss of generality. The final adjusted values of the objective function coefficients for (9) are provided in Table 3.

Table 3 The results of the PROMETHEE II analysis

Rank	Supplier	ϕ_j	$\phi_j + q$	Rank	Supplier	ϕ_j	$\phi_j + q$
1	S15	0.4008	0.7267	10	S1	-0.0167	0.3092
2	S17	0.3953	0.7212	11	S9	-0.0438	0.2821
3	S10	0.2204	0.5463	12	S16	-0.0671	0.2588
4	S5	0.1546	0.4805	13	S3	-0.0994	0.2265
5	S8	0.0915	0.4174	14	S2	-0.1399	0.186
6	S11	0.0794	0.4053	15	S18	-0.1866	0.1393
7	S6	0.0513	0.3772	16	S4	-0.2879	0.038
8	S13	0.0498	0.3757	17	S7	-0.3005	0.0254
9	S12	0.0246	0.3505	18	S14	-0.3258	0.0001

The company needs 10 products P1-P10 for production in quantities d_i provided in Table 4. Each product can be delivered by at least two suppliers to avoid trivial results. The selling prices per one product can differ with suppliers, see the values typeset with upper indices in Table 4. The last remaining input value for (9) is the upper bound for the total delivery costs b. It is assumed that the company is not able to set this value. Therefore, in the first instance, the model (9) is run without the budget constraint (5d) and the obtained results are further used for the sensitivity analysis exploring the restrictive effect of the budget constraint.

Table 4 Available numbers of products with their selling prices (in bold)

	S1	S2	S3	S4	S5	S6	S7	S8	S9	d_i
P1	10 **6**	0	0	20 **8**	0	0	0	0	0	15
P2	0	0	30 **5**	40 **6**	0	0	0	30 **7**	0	60
P3	0	0	0	50 **7**	0	0	20 **6**	0	0	70
P4	0	20 **2**	0	0	100 **3**	0	0	0	0	120
P5	0	0	0	0	40 **5**	30 **5**	0	0	40 **4**	80
P6	0	25 **6**	0	0	50 **5**	0	0	60 **5**	0	70
P7	0	0	0	0	0	0	0	50 **9**	0	40
P8	0	0	0	0	0	0	90 **4**	0	0	100
P9	0	0	0	0	0	0	0	0	0	100
P10	0	0	0	0	0	0	0	0	0	100

	S10	S11	S12	S13	S14	S15	S16	S17	S18
P1	0	0	0	30 **7**	0	0	0	0	0
P2	0	80 **4**	0	0	60 **6**	0	0	0	0
P3	0	0	0	50 **9**	0	0	0	0	0
P4	0	50 **1**	0	0	80 **2**	0	0	100 **3**	0
P5	0	0	0	50 **5**	0	50	0	30 **4**	0
P6	60 **4**	0	0	0	0	0	60 **3**	0	0
P7	60 **10**	0	50 **8**	0	0	50 **9**	0	0	0
P8	80 **5**	0	0	0	0	0	0	90 **5**	0
P9	120 **4**	0	0	0	0	80 **5**	0	0	70 **3**
P10	80 **4**	0	0	0	0	0	0	0	100 **3**

In line with [12], the model is run for different values of portfolio size c, in order to get the so called c-optimal portfolios. In the first instance, the model is run without the constraint (5e) to get the upper bound $\bar{c}$ for c. Then the model is run repeatedly with gradually decreasing c until the feasible solution exists (i.e., for $c = \bar{c}, \bar{c}-1, \bar{c}-2, \ldots, \underline{c}$, where $\underline{c}$ is the minimal c, for which the model remains feasible).

The model (9) is solved using the MIP solver of GAMS software and a computer with I7 Intel processor 2.59GHz, 16GB RAM and Windows 10 x64 OS. The model contains 216 variables (180 real variables and 36 binary variables) and 228 constraints (excluding non-negativity constraints and binary constraints) in total.

4.1 Results and discussion

The results of the model (9) without the budget constraint for different values of c are provided in Table 5. It can be seen that the optimal portfolio without the constraint on size contains 9 suppliers (thus, $\bar{c} = 9$) and the model is feasible for $c \geq 7$ (thus, $\underline{c} = 7$). The corresponding optimal values of the objective functions are shown in Table 6.

One can expect that when c is decreased by 1, one (the least suitable) supplier will be excluded from the portfolio and the remaining suppliers will still be selected. But, the results in Table 5 shows that this is not true in general, see the supplier S11 that is in the c-optimal portfolios for $c = 7,9$, but not for $c = 8$.

Table 5 The optimal portfolios based on the new proposed approach and their comparison with the previous approaches by [9] and [11] without bound c (i.e., $c \leq 18$), and for $c = 7$ and $c = 8$

	The approach proposed in this paper																	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
$c = 7$	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1
$c = 8$	0	0	0	1	1	0	0	1	0	1	0	0	1	0	1	0	1	1
$c \leq 18$	0	0	0	1	1	0	0	1	0	1	1	0	1	0	1	0	1	1
	The original PROMETHEE V by [9]																	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
$c = 7$	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1
$c = 8$	0	0	0	1	1	0	0	1	0	1	0	0	1	0	1	0	1	1
$c \leq 18$	0	0	0	1	1	**1**	0	1	0	1	1	**1**	1	0	1	0	1	1
	The approach proposed by [11]																	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
$c = 7$	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1
$c = 8$	0	0	0	**0**	1	0	**1**	**0**	0	1	**1**	0	1	0	1	0	1	1
$c \leq 18$	**1**	**1**	**1**	1	1	**1**	**1**	1	**1**	1	1	**1**	1	**1**	1	**1**	1	1

Table 6 The total utility expressed by the objective function in (9)

	This study	Brans and Mareschal [9]	Mavrotas et al. [11]
$c = 7$	382.57	170.79	170.79
$c = 8$	431.12	171.55	171.55
$c \leq 18$	442.14	173.82	179.11

Table 5 includes also the results of the problem solved using the original PROMETHEE V method and the modified version by [11] (differences are typeset in bold). The most differences can be found in the models unconstrained in size. Unlike the approach proposed in this paper, the results of the model solved with the original approach [9] include 11 suppliers in the optimal portfolio (S7 is replaced by S6 and, in addition, S8 and S12 are added). The results using the approach by [11] bring no surprising results - all the suppliers under consideration are selected to the optimal portfolio. Two reversals occur for $c = 8$: S4 and S8 are replaced by S7 and S11 for the model based on [11], meanwhile the results based on [9] are identical to the new proposed approach in this case. The optimal portfolios are the same for the smallest feasible size, i.e., $c = 7$. The optimal values of the objective functions can be found in Table 6. For the sake of comparability, all the optima are calculated using the objective function in (9), i.e., the values obtained by two compared approaches must be recalculated accordingly. It is not surprising that the new approach brings the best values. But, it is worth noticing that the new approach performs more than twice better in comparison with the other two models for all three scenarios of c (note that this is approximately the same difference as in the example in Figure 2 where the solutions could be evaluated intuitively).

Despite the optimal portfolios for all three compared approaches are identical for $c = 7$, the structure of supplies y_{ij} differs for the new approach (M1) and others (M2,M3), as it is signaled by the values in Table 6, see Table 7. Differences in values are typeset in bold. One difference deserves a special comment: based on the input data, S18 must be selected because another supplier who provides P10, i.e, S10, cannot satisfy the whole demand equal to 100. However, this supplier performs very poorly according to the PROMETHEE ranking (see Table 3). In spite of this, the approaches designated as M2 and M3 assign the whole demand to S18 because the delivered quantity does not influence the value of the objective function. The solution M1 should be definitely preferred. It is worth noting that this solution is an alternative optimal solution even for M2 and M3, but the probability that this solution is found by their corresponding models tends to zero.

Table 7 The optimal distribution of supplies for c=7 and three compared approaches

		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
P1	M1	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0
	M2,M3	0	0	0	0	0	0	0	0	0	0	0	**0**	**15**	0	0	0	0	0
P2	M1	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0
	M2,M3	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0
P3	M1	0	0	0	0	0	0	20	0	0	0	0	0	50	0	0	0	0	0
	M2,M3	0	0	0	0	0	0	20	0	0	0	0	0	50	0	0	0	0	0
P4	M1	0	0	0	0	100	0	0	0	0	0	20	0	0	0	0	0	0	0
	M2,M3	0	0	0	0	**70**	0	0	0	0	0	**50**	0	0	0	0	0	0	0
P5	M1	0	0	0	0	30	0	0	0	0	0	0	0	0	0	50	0	0	0
	M2,M3	0	0	0	0	**40**	0	0	0	0	0	0	0	0	0	**40**	0	0	0
P6	M1	0	0	0	0	10	0	0	0	60	0	0	0	0	0	0	0	0	0
	M2,M3	0	0	0	0	10	0	0	0	**0**	**60**	0	0	0	0	0	0	0	0
P7	M1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0
	M2,M3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0
P8	M1	0	0	0	0	0	0	20	0	0	80	0	0	0	0	0	0	0	0
	M2,M3	0	0	0	0	0	0	**90**	0	0	**10**	0	0	0	0	0	0	0	0
P9	M1	0	0	0	0	0	0	0	0	0	20	0	0	0	0	80	0	0	0
	M2,M3	0	0	0	0	0	0	0	0	0	**10**	0	0	**0**	0	0	0	0	0
P10	M1	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	20
	M2,M3	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	**100**

Another analysis of the optimal supplies' structure is done for three scenarios of c values (again for $c = 7{,}8$ and $c \leq 18$). Figure 2 shows the results of this analysis. If the size of the portfolio is reduced from 9 to 8, only one change occurs – S8 is excluded from the portfolio and its quantity is covered by S11. On the contrary, when c is reduced to 7, the exclusion of S17 leads to many complex changes in the optimal portfolio.

As to the total delivery cost, if there is no budget constraint b set upon the model, the total costs for $c = 7, 8, 9$ are equal to 3,625; 3,825; 3,765 respectively. The minimum of the delivery cost, for which model (9) remains feasible, equals 2905, i.e., (9) brings more expensive solutions almost by 25%. The company can reduce these costs using a budget bound b (5d). An effect of this bound on the optimal solution of the model (9) is explored within the sensitivity analysis in Section 4.2.

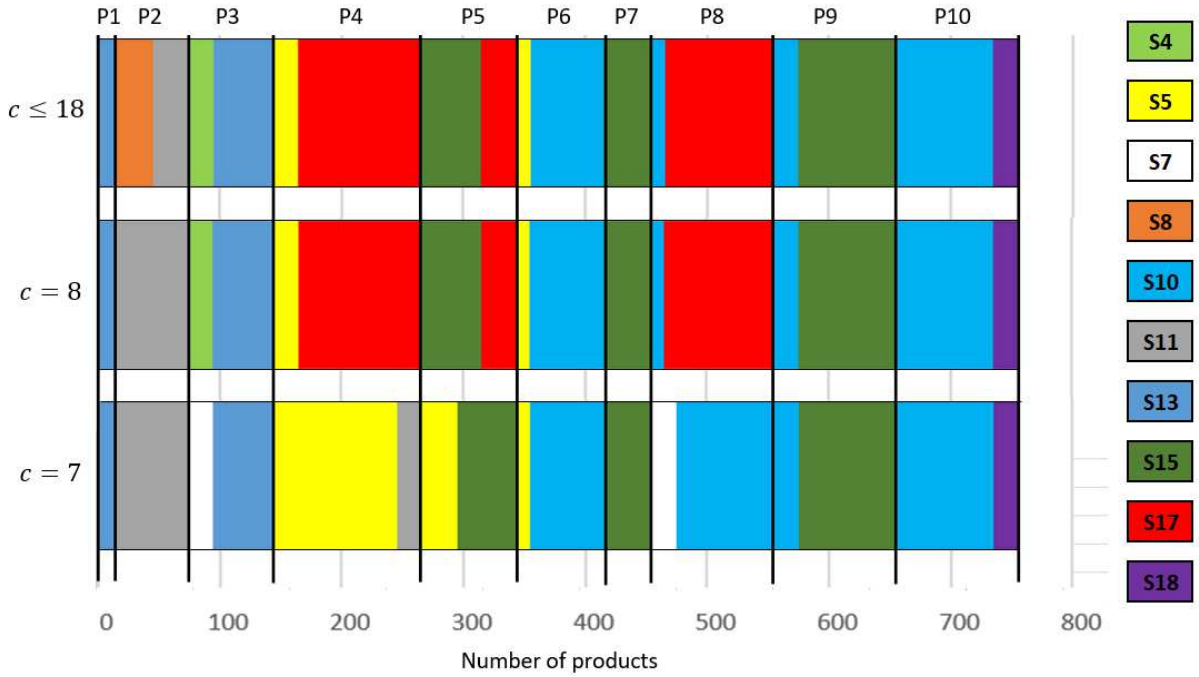

Figure 2 Optimal structure of supplies for the numerical example solved by the new proposed approach with different sizes of portfolio

4.2 Sensitivity analysis

In this section, it is explored how the optimal solution of the solved numerical example changes when the company limits its total delivery cost by various values. It has been shown that if the company does not restrict the budget, nor the portfolio size, the highest cost equals 3,765 units. On the contrary, the minimum value of the cost, when ignoring the PROMETHEE rankings of the suppliers, is equal to 2,905. It is reasonable to expect that the company requires to reach the budget *substantially lower* than the one given by model (10). In this way, it is possible to avoid determining a precise value. In line with [20], such vague constraint can be solved using the flexible programming approach where the uncertain relation is expressed by a fuzzy set. Namely, the basic Verdegay's model with vague constraints is used here. *Substantially lower than 3,765* is replaced by the non-increasing fuzzy interval depicted in Figure 3. The membership degree α represents to what extent the company is satisfied with the value of costs. Certainly, it is absolutely satisfied when the cost equals the absolute minimum of 2,905 units and it is not satisfied at all if the cost is greater than or equal to 3,765 units.

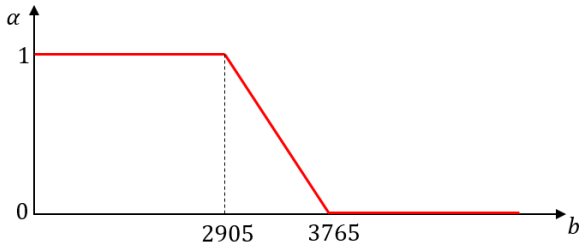

Figure 3 Fuzzy interval describing the uncertain 'Substantially lower than 3,765' relation

According to [20], the deterministic form of the given vague constraint is as follows:

$$\sum_{i=1}^{m}\sum_{j=1}^{s} p_{ij}y_{ij} \leq 3765 - 860\alpha \qquad (10)$$

where 860 is the difference between the cost of absolute dissatisfaction (3,765) and absolute satisfaction (2,905).

Table 8 The results of the numerical example with flexible constraint on the total delivery cost (OF = objective function value)

α	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	OF
0	0	0	0	1	1	0	0	1	0	1	1	0	1	0	1	0	1	1	442.14
0.1	0	0	0	1	1	0	0	1	0	1	1	0	1	0	1	0	1	1	441.79
0.2	1	0	0	0	1	0	1	0	0	1	1	0	1	0	1	1	1	1	428.02
0.3	1	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	424.62
0.4	1	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	410.05
0.5	1	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	393.47
0.6	1	0	0	1	0	0	1	0	0	1	1	1	1	0	1	1	1	1	364.48
0.7	1	0	0	1	0	0	1	0	0	1	1	1	1	0	1	1	1	1	329.47
0.8	1	0	0	1	0	0	1	0	1	1	1	1	0	1	1	1	1	1	293.42
0.9	1	1	0	1	0	0	1	0	1	1	1	1	1	0	1	1	1	1	241.56
1	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	180.45

The model (9) will be solved again, but with (d) constraint replaced by (10) for $\alpha \in [0,1]$ (particularly for $\alpha = 0,0.1,0.2,\ldots,1$). The results are provided in Table 8. It is not surprising that the optimal values of the objective function decrease with increasing level of satisfaction with the budget constraint (10) since the model is more restricted. On the other hand, the portfolio size increases with increasing α. But, it is worth noting that the optimum of the objective function for maximum satisfaction with the budget constraint (i.e., $\alpha = 1$) is still greater than the values of the same function for the optimal solutions of the compared approaches without the budget constraint in Section 4.1, see Table 6.

5 Conclusions

In this paper, the authors focused on the supplier portfolio selection problem. Namely, it was shown how the PROMETHEE outranking method can be used to solve this kind of economic problem. A general model with the constraints applicable to the vast majority of production companies has been built, and, using this model, it was demonstrated that the original PROMETHEE V method [9] can distort the final decision. This drawback stems from the logic how the utility of portfolios is measured. In the original method, the evaluation is based only on the selected suppliers regardless of the quantities delivered by these suppliers. This fact strongly favors large portfolios by crumbling the supplies among the suppliers with positive values of the net flows resulting from the PROMETHEE II ranking. The second drawback, which has already been many times discussed by researchers, is that the original PROMETHEE V discriminates the suppliers with negative values of the net flows. Therefore, the authors came with the modification of the objective function of the PROMETHEE V optimisation model. To deal with the former drawback, each portfolio was evaluated using not only its structure, but it was also taken into account how many items the selected suppliers supply. The latter drawback was eliminated using the approach by [11]. Despite the authors of [13] has proved this approach unsuitable because it favors large portfolios even more than

the original method, it is convenient for the proposed approach when it is applied together with the proposed change in the logic of portfolio evaluation.

Using the numerical example, the proposed approach has been compared with the original one. The optimal decisions of the compared approaches can differ in the portfolio structure and supplied quantities. As to the optimal structure of suppliers, the new approach brings more satisfiable results if the portfolio size is not explicitly restricted by the constraint (not all the suppliers with the positive values of the PROMETHEE net flows are necessarily selected, unlike the original approach). Concerning the optimal supplied quantities, the results of the new and original approaches differ a lot because the original model does not involve these quantities in the objective function. In our opinion, the new approach brings the results closer to practice for the considered economic problem.

The sensitivity analysis, which was done using the flexible fuzzy constraint on the budget, showed that the size of the portfolio increases with a degree of satisfaction with the budget level. Moreover, the total utility of the optimal portfolios of suppliers was greater than the total utility brought by the original PROMETHEE V recalculated using the new proposed objective function for all degrees of satisfaction with the budget level.

It was shown that the PROMETHEE V approach is a suitable method to solve the supplier portfolio selection problem with the proposed modification of an objective function, which takes into account not only the structure of portfolio, but also the quantities delivered. The solution is non-trivial and it brings a consistent and desired quantitative support for the decision. On the other hand, if only the portfolio structure matters, and no other accompanying decisions, e.g., on quantities related to the alternatives, must be done, the new approach is useless, and the original logic must be used for the objective function. The authors are also aware of another potential weakness of the proposed approach. It was supposed that the utility of each portfolio depends on the PROMETHEE II rankings and delivered quantities. But, one can admit that, sometimes, the supplied quantities are not the main driving factor. For example, if a construction company plans to order 1,000 nails and only one automatic nailer, it can be reasonable to suppose that the marginal utility brought by delivery of a single item differs in favor of substantially more expensive and reusable nailer. The future research can be focused on other possible modifications of the objective function used in the PROMETHEE V method for various real-life economic applications. Another direction of extension could be the extension of the model with the significance (weights) of the suppliers as the authors of [21] proposed.

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MODERN MODELS OF ECONOMIC DEVELOPMENT: TRANSFORMATION OF TARGETS, EVALUATION AND CLUSTER ANALYSIS

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Keywords: economic development model, cluster analysis.
Abstract: The key goal of the study is the formation of scientific and methodological approaches to the analysis of modern models of economic development of countries. The features of the models of economic development of countries, their types and specifics are considered, the transformation of indicators of economic development of the countries of the world in the context of global imbalances and volatility is argued. It is proved that the key factor in the sustainable development of the country is economic growth, which ensures the overall well-being of both a separate industry and the country's economy as a whole. The specificity of the transformation of key indicators of the economic development of countries is considered; this served as the basis for substantiating the scientific and methodological aspects of the multidimensional cluster analysis of the target indicators of the economic development of the countries of the world. The scientific and methodological aspects of the multidimensional analysis of the transformation of the target indicators of the economic development of countries were formed, which ensured the structuring of countries into groups of economic development, taking into account the specifics of their functioning and development strategies. The application of the developed approaches based on the economic and statistical multidimensional cluster analysis and indicators of economic development of the countries of the world can be applied in practice. The developed scientific and methodological recommendations will ensure the effectiveness of the formation of economic policies and strategies for the economic development of countries.

1 Introduction

The main goal of the study is to develop scientific prerequisites for evaluating modern models of economic development and substantiate methodological approaches to determining the features of their transformation.

The need for this study is determined by the lack of a unified approach and concept to the formation of a model of the country's economic development. The relevance of this issue is determined by the current trends of global changes in the world economy, which necessitate the revision of existing models of economic development and their transformation in accordance with global trends.

The conceptual basis for the functioning of the world economy is the constant transformation and adaptation of models of economic development of countries under the influence of various processes of globalization and integration, on the one hand, and the basic principles of the mechanism of economic evolution, on the other hand. In modern realities, economic development models are a key link, which include a number of factors, elements and tools

to ensure the strategic goals of both a separate industry and the country as a whole.

The main object of the study is the level of economic development of countries, and the information base is a set of specific examples of the economic development of countries, statistical materials, economic and mathematical hypotheses and forecasts that characterize trends and tendencies of economic growth. To solve the set tasks and achieve the goals of the study, special attention is paid to the peculiarities of the formation of economic models of countries depending on a number of factors, such as socio-economic and political strategies, as well as macroeconomic and global trends in the development of the world economy. In modern conditions, the choice of strategic development goals and ways to achieve them is possible on the basis of a deep study of the economy and models of economic development of countries.

Modern trends in the functioning of the world economy are characterized by the need to constantly search for new approaches, techniques, strategies and solutions in the context of the formation of sustainable economic models. In modern economic literature, there is no unified approach to the analysis and evaluation of the transformation of the target indicators of the economic development of countries, which determines the relevance and need for further research.

The presented aspects led to the need for a more detailed study and structuring of the main modern models of economic development and identification of the main aspects of the transformation of target indicators in order to develop scientific and methodological approaches for their evaluation and application in practice. In connection with the presented, it is worth noting that in order to achieve the main tasks and objectives of the study, the authors of the article will structure scientific approaches in the field of economic development of countries, conceptualize and structure the main economic models, which will allow to substantiate and form the scientific and methodological aspects of the analysis and assessment of the features of the transformation of key indicators economic development of countries. A critical analysis of scientific research in the field of economic development of countries allowed the authors to conceptually determine the lack of a unified approach to assessing modern models of economic development of countries, which requires more detailed study and research.

1.1 The theory of formation of models of economic development in the conditions of transformation of the world market

In modern conditions, the choice of strategic development goals and ways to achieve them is possible on the basis of a comprehensive study of the economy and models of economic development of countries, as well as the adaptation of the main theoretical provisions to the specific socio-economic conditions of development in the country. In order to determine an appropriate model of economic development that reflects a specific theoretical and applied vision of the mutual influence of the economic development of individual countries, the most important task of any economic system is to ensure sustainable and balanced development. It should be noted that in the modern economic space, many scientists have many approaches to the definition of the concept of economic development, sustainable economic development, but there is no single approach, which requires a more detailed study. A critical analysis of scientific views made it possible to structure the concept of "sustainable economic development", which should be understood as economic growth, which is characterized by its intensity and does not harm the environment, and also contributes to the resolution of a number of critical socio-economic problems, finding the optimal middle between economic, environmental and social development. It is worth noting that sustainable economic development, as a concept, was first born in 1970-1980 against the backdrop of the recognition by the world community of the problems of the development of society and science in the face of limited natural resources and environmental conditions. It should be noted that the presence of many studies in the economic literature does not allow us to single out a unified approach and method of management to ensure sustainable economic development, which requires a deeper study aimed at solving a number of topical issues.

The first researchers of economic development were a group of the following economists: [1,2], who considered the relationship between the growth of total income and the total product of the country as the basis of its economic development. It should be noted that this approach is a classic of economic science and does not take into account current trends in the globalization of the world economy and its transformation. Also noteworthy is the scientific approach of a group of scientists [3,4], who considered the interdependence of the growth of the country's welfare with the growth of total income. This approach determines the key dependence of these factors within a particular country, but takes into account conceptually the entire range of factors that may have an impact on the country's economic development. Similar views are highlighted in scientific papers [5,6], which highlight the dependence of the country's economic development on domestic policy and socio-economic aspects, but this approach does not take into account macro components that can significantly change the economic development strategy, which requires more detailed study.

Of particular interest is the study of a group of scientists: [7,8], who study short-term conceptual problems that are associated with the distribution of income within the country, but this approach is not relevant in modern realities and requires significant improvement and the search for new approaches. Consideration of the features of the theory of costs and general equilibrium in the country's economy in scientific research: [9,10],

determines the general features of managing economic policy by maintaining balance and equilibrium, without taking into account global changes, which is not entirely relevant in modern conditions and requires more detailed study, research and improvement.

Particular attention should be paid to scientific works [11-13], which are aimed at considering the population and technological progress as autonomous factors that contribute to economic development. It should be noted that this approach is fundamental in the field of the formation of economic science and the study of economic development, but takes into account a narrow list of factors in the short term, which does not correspond to modern business realities in the context of transformational processes.

A significant contribution to the study of the main aspects of economic development in the world was made by such economists and specialists as: [14,15], who single out the construction of a process of sustainable economic development as one of the strategically important aspects of the long-term growth of a separate sector of the economy. This approach is relevant in modern conditions, but is based only on a specific area, industry, which requires a wider scale and study. Scientific studies [16,17] are argued for the strategic and long-term development of the economy of the whole country, but do not take into account all global factors that can significantly affect the strategy, which requires more detailed study and improvement. Based on the presented, it is worth noting that in the absence of a unified concept of sustainable economic development, the issue of a deeper theoretical analysis and development of a methodological component of the organization of effective sustainable economic development remains relevant.

In modern economic literature, the interpretation of the essence of the concept of "model" has two meanings for understanding, namely: 1) visual reflection and description of any phenomena or processes in society; 2) a template that helps set an example for reproduction and implementation in practice.

The conceptual need to study the models of economic development of countries leads to the identification of the essential characteristics of economic development as the main driving force of progress, on the one hand, and, directly, the phase of economic evolution, on the other. According to the scientist [14], the economic interests of people associated with property relations, depending on the real forms of ownership of the means of production, are a powerful generator of development.

However, this approach cannot be implemented in modern realities, since it does not take into account global macroeconomic factors influencing sustainable economic development. A group of scientists such as: [18-20] considers the complex nature of transformations in the conditions of economic development, covering profound changes in the technical, economic, social, political, institutional spheres, in the field of infrastructure, technology, education, as well as in the field of basic factors of production: capital, natural resources, labor. It should be noted that this approach includes a large number of factors that affect the sustainability of economic development, but does not take into account the processes of globalization and internationalization, which have a significant impact in modern conditions of functioning.

More relevant and close to modern realities is the approach of a group of scientists, such as: [21-23], economic development is seen as the emergence of something new, previously unknown. It should be noted that diverse studies in the field of economic theory and economic development allow us to conclude that today there is no single approach to understanding the model of economic development, which requires a deeper analysis and research. Economic development is efficient and a growing economy is always in the process of reducing or eliminating poverty, inequality and unemployment.

The economic growth of the economy of any country is an increase in welfare, per capita income, an increase in the quality of life and a better satisfaction of the basic needs of all members of society. Thus, economic development is a multi-vector process, including the transformation of the entire economic and social system, leading to fundamental changes in social structures, people's behavior, social institutions and, as a result, accelerating economic growth, reducing inequality and eliminating unemployment. Economic growth in the current conditions of the transformation of the world economy under the influence of the processes of globalization and internationalization is aimed at the following areas:

1) increasing the supply and ensuring the availability of essential goods and services (food, housing, health and safety);

2) raising the standard of living - increasing the income of the population;

3) an increase in the number of jobs - a decrease in the share of unemployment;

4) improving the quality of educational services in the world, as a key factor in forming a literate society;

5) increased attention to cultural and humanitarian values.

Ensuring the directions of economic development presented above will ensure the growth of material well-being, personal and national self-consciousness, providing individuals and society as a whole with a greater choice in the economy and the social sphere in order to reduce their influence and dependence on other people and countries and protect them from suffering. It is important to note that the uneven pace of development of individual countries of the world contributed to the identification of certain ways of their development and the formation of generalized patterns (models), which are understood as the totality of all economic processes carried out in society on the basis of existing property relations and organizational forms.

Arguing the considered theoretical aspects and studies in the field of economic development of countries, it is

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worth noting that in many studies the concepts of "economic development" and "economic model" are often equated. Based on this, it is worth defining these concepts. Economic development is a broader concept and is based on expanded reproduction and gradual structural changes in all sectors of the economy of a particular country.

In modern conditions, economic development includes the entire spectrum of social relations, including the development of economic sectors and the redistribution of public goods. An economic model is a narrower concept and is based on the formalization and description of the main economic phenomena and processes, specifying the key elements of the economic system. Based on the above, it should be argued that under the influence of a combination of heterogeneous factors, each country develops its own model of national development, which is the result of the implementation of the chosen strategy, which has a specific goal, achieved through the application of effective socio-economic policy measures.

It should be noted that the very model of economic development was formed by combining such basic areas as: economic, social and environmental. From the point of view of economic orientation: long-term economic projects that take into account the laws of nature, as a result, turn out to be more effective than projects whose implementation does not take into account possible environmental consequences. From the point of view of social orientation, it became the impetus for the formation of this concept, aimed at maintaining cultural and social stability, as well as at reducing the number of conflicts that destroy them

Economic development should be carried out taking into account many factors of the macroeconomic environment that have a direct impact on its sustainability and presented in Figure 1.

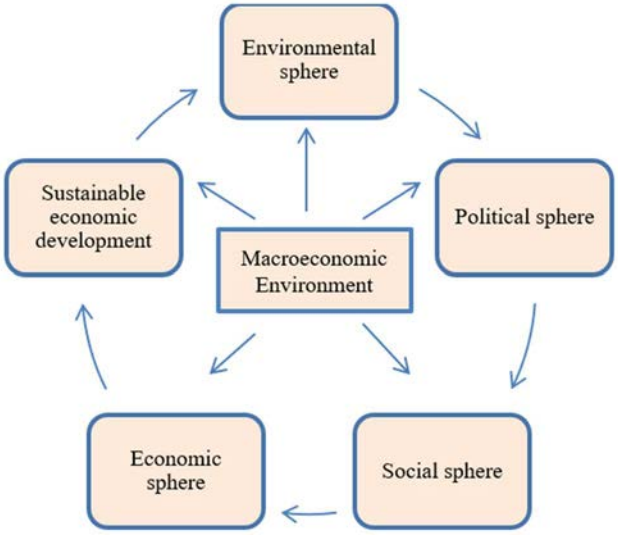

Figure 1 Modern economic development, taking into account the influence of the macroeconomic environment
Source: developed by the author

Ecological direction, the main purpose of which is to ensure the sustainability of physical and ecological systems. Ignoring environmental needs will lead to environmental degradation and threaten the existence of all mankind. However, the modern model is based on these postulates of ensuring the sustainable development of the economy, but must take into account the risks and factors that are associated with the influence of political factors that exacerbate the macroeconomic impact among the negative impacts on economic processes.

2 Methodology

2.1 Peer review process

To determine global changes and transformation of target indicators of economic development, a critical analysis of scientific research in this area was justified, which made it possible to determine the lack of a unified approach and confirmed the relevance of this study. Scientific views and studies are structured according to their significance within the framework of this topic, the main groups of studies are summarized, which made it possible to highlight the key theoretical aspects in the formation of an economic development model. The necessity of structuring and considering the economic essence of the concepts of "economic development" and "economic model" is argued; for the first time, their features are defined in the narrow and broad senses. On the basis of theoretical prerequisites, the necessity of conceptualizing and highlighting the main aspects of the transformation of key indicators of economic development is argued.

The main key indicators of economic development are classified, on the basis of which the need for economic and statistical analysis and the use of multidimensional cluster analysis tools is substantiated. The tools of economic and statistical analysis made it possible to determine the main indicators of economic development and the features of their transformation under the influence of global factors of globalization and internationalization in the context of many countries of the world.

This tool is a multidimensional statistical procedure that organizes the selection of objects into homogeneous groups, i.e., gets a set of clusters. the main objectives of multidimensional clustering are understanding the data with further simplification of processing procedures; data compression and detection of new atypical objects. Currently, the most common are about 50 clustering methods. The implementation of cluster procedures is usually associated with a number of parameters, the most important of which are: the degree of similarity between elements and clusters, the value of the equivalence threshold for this measure, based on which the assignment or non-assignment of an object to a cluster. Also important are the number of clusters and the approach related to the specific approach and the direct value of the criterion that evaluates the quality (efficiency) of clustering.

In order to substantiate the scientific and methodological foundations of multidimensional cluster analysis of economic development of countries in the world are considered as separate, independent clusters of one element. To determine the key clusters of countries by the level of economic development in the world, it is advisable to use multidimensional cluster analysis and the method of k-means (k-means). This method k-means is an iterative procedure that divides a given set of elements into k clusters, the points of which are as close as possible to their centers, and the clustering itself is due to the displacement of these centers. The method seeks to minimize the total quadratic deviation of the cluster points from the centers of these clusters (efficiency criterion). An important step in conducting a multidimensional cluster analysis of the economic development of the world is to select the right method for calculating the distances between the studied objects (groups). Euclidean distance (1), which is the geometric distance in multidimensional space and is calculated as follows, is most often used in economic research:

$$dij = \sqrt{\sum_{k=1}^{m}\left(X_{ik} - X_{jk}\right)^2} \quad (1)$$

where: d_{ij} is the distance between objects *i* and *j*; x_{jk} is the value of the k-th variable for the *i-th* object;
x_{jk} is the value of the k-th variable for the *j-th* object.

It should be noted that the Euclidean distance (and its square) is calculated based on the input data and is the standard way to calculate the distance between the studied objects. This method has some advantages (for example, the distance between two objects does not change when a new object is analyzed), but the distance can be greatly affected by the differences between the units of measurement on the axes on the coordinates of which these distances are calculated.

In this case, the Euclidean distance (or the square of the Euclidean distance), calculated on the basis of coordinates (2), varies significantly, and, as a result, the results of multidimensional cluster analysis may differ greatly from the previous ones.

$$dist(x,y) = max|x_i - y_i| \quad (2)$$

where: *dist (x, y)* is the distance between objects *x* and *y; x_i* is the maximum value for the *i-th* variable for *x* object; y_j is the maximum value for the *j-th* variable for the *y* object.

In the scientific literature, sometimes for the progressive increase or decrease of weight related to the dimension for which the respective objects differ significantly, which can be achieved using a degree distance. When performing multidimensional cluster analysis, the power distance is calculated by the formula (3):

$$dist(x,y) = \left(\sum_i |x_i - y_i|^p\right)^{\frac{1}{r}} \quad (3)$$

where: *dist (x, y)* is the distance between objects *x* and *y*; x_i is the value for the *i-th* variable for *x* object; y_j is the value for the *j-th* variable for the *y* object; *p* is the parameter responsible for weighing the differences in each of the coordinates. The *r*-parameter is responsible for weighing large distances between objects.

The main purpose of multidimensional cluster analysis of economic development of the world is to divide the multidimensional set of input data into homogeneous groups so that objects within the group are similar in terms of economic development, and objects from different groups differ from each other. The formation of the model of economic development of the country should be scientifically sound and based on the methodological and methodological level. In today's conditions of transparency and large amounts of information, the formation of an effective model of economic development in many cases is impossible without the analysis of its key objects, factors based on the use of multidimensional cluster analysis.

The developed scientific and methodological aspects of assessing the economic development of countries on the basis of a multidimensional cluster analysis, in contrast to the existing ones, take into account the maximum number of objects of the economic development model and factors of the macroeconomic environment that have a significant impact on it.

The use of all the tools and methods proposed by the author made it possible to form the theoretical prerequisites and develop methodological aspects of assessing the key indicators of the economic development of countries that can be applied in practice by the leaders of both a separate industry and the country's government in strategic management to predict, evaluate and analyze the impact of macroeconomic factors on model of economic development.

3 Result and discussion

It is important to note that the transition from an industrial society to a post-industrial one, the formation of an informational mode of production, an increase in the action of a qualitatively new factor of production - information and knowledge, the spread of a new, innovative type of development, as well as a shift in the vector of economic development to the social side, in which a person with new the qualitative characteristics of their activities, such as creativity, the desire for self-expression and self-development - to make adjustments to the model of economic development.

So, among the basic models of the development of a market economy, the American (or liberal) model, the

model of a socially oriented market economy, the British model and the market model of newly industrialized countries stand out. It should be noted that recently the postulates of the concept of the welfare state as a desirable option for socio-economic development have been declared in economically developed countries. In this regard, the classification of three models of development of the national economy deserves attention:

1) a liberal-oriented model of the development of the national economy (the "American, Anglo-Saxon" model of capitalism) with minimal government obligations that apply only to the poorest part of the population;

2) the social democratic model ("Swedish, Scandinavian" model of capitalism), focused on equalizing the incomes of all members of society through a progressive system.

3) model of social market economy (model of capitalism "Central Europe, Rhine").

It is a corporate model with a well-developed payroll social insurance system.

Taking into account the specifics of changes in economic systems and the impossibility in some cases of applying quantitative assessment criteria, modeling of economic development cannot be determined on an empirical basis, but can be carried out by analyzing its various directions with an emphasis on certain aspects. As part of the review of this study, target indicators of economic development models.

An indicator (from the Latin. Indicator - pointer) in sociology is understood as a characteristic of the object under study, available for observation and measurement, which makes it possible to judge its other characteristics that are inaccessible for direct research. It should be noted that in the economic literature, the indicator is:

1) a tool for qualitative and quantitative interpretation of goals and performance measurement;

2) the parameters of the boundaries in which the system, including organizational mechanisms, technological connections, material and financial flows, can function and develop stably.

A specific feature of indicators is their vector orientation. Given this peculiarity, it can be stated with confidence that the target indicator of economic development models is a certain object (element) of management, acting on which, assistance is made to improve management, which ultimately contributes to the long-term stability and competitiveness of this model. The industrial development model is relevant in the face of large economic problems or the demands of economic goals. The economy is seen as the goal of public policy, and not a means of achieving the main goal - the well-being of citizens. Gross Domestic Product (GDP) in this model is the main indicator of national progress. China is an example of the successful use of the industrial development model at the present stage. The main types of models for the development of a market economy, their characteristics and features (Table 1).

Today, the Chinese model of development is becoming more and more complex, new guidelines are emerging - innovation, social and regional development, high-quality public services to the population, etc. The model of mobilization development is chosen by countries that are pursuing catch-up development. track; it can exist in any form of economy - both market, non-market, private and public. Moreover, it is characterized by a multitude of structures, when some sectors of the economy and society come in a state of mobilization, while others do not. The transformation processes of economic development models and its target indicators, which are more fully reflected in the development strategy, determine modern conditions for the functioning of the economies of countries.

Competitiveness model. This model is relevant for the development of countries and regions in the face of increasing external influences and uncertainty. Competitiveness characterizes the integral ability of a territory (country, region, city, etc.) to adequately respond to external challenges and opportunities, maintain systemic stability and provide favorable conditions for the economy and livelihoods of the population.

Competitive models are based on four economic determinants that shape the environment that promotes or inhibits development. These four determinants are: factor conditions; domestic demand conditions; related industries and services; the strategy of firms, their structure and rivalry. In addition to the above, there are two other variables that can either enhance or weaken the synergistic effect of the interaction of these four factors - random events and government actions.

The sustainable development model was ratified at the 1992 United Nations Conference on Development and Environment in Rio de Janeiro. Today this concept is the most widespread and is often referred to as the "global model of the future civilization". The application of a sustainable development model contributes to solving current problems, which should not pose a threat to future generations to satisfy their interests.

Recall that the concept of "sustainable development" includes not only environmental and resource aspects, but also socio-economic and political aspects, which has actualized the need for more active use of intersectional and territorial approaches in public policy. Many states have accepted this as necessary for further development.

Smart development model. The smart sustainable development model seeks to ensure that information and communication technologies are used for both development and disaster management to improve the lives of millions of people around the world, which is a resource challenge. Constraints, international and interregional competition, emerging new technologies, etc. It is based on a combination of innovation and rational solutions for the use of available resources, as well as on the possibilities of increasing productivity without harming the environment and at the same time improving the quality of life.

Smart development model. The smart sustainable development model aims to ensure that information and communication technologies are used for both development and disaster management to improve the lives of millions of people around the world, which requires resources.

Table 1 The main types of models for the development of a market economy, their characteristics and features

Model	Countries	Characteristic and features of the model
American (liberal) model	USA	- emphasis on freedom of enterprise and the power of competition; - the state regulates those aspects of production that are not amenable to effective regulation on the basis of free competition; - a higher level of private investment in relation to the state; - low proportion of state ownership; - a sharp differentiation of the population between rich and poor; - a big difference in the level of wages; - an acceptable standard of living for low-income groups.
Model of a socially oriented market economy	Germany, Sweden, Japan	German model – "Social market economy" - Creation of equal conditions for self-realization of a free, independent, state-abiding, law-abiding and creative person; - Presence of a "mixed economy" with a large share of state ownership; - Macroeconomic regulation is carried out by such levers as monetary, tax and budgetary policy and structural policy. Swedish model – "Democratic socialism" - Preservation of a market economy based on private property; - Powerful socialization of the distribution of national income through the use of the tax transfer mechanism; - Development of a system of social support for the population (the expenses for social support of the population are borne by the state; these expenses constitute a significant part of the state budget). Japanese model – "Japanese miracle" - The state contributes to the creation of superpower corporations formed around the bank, which became the center of such a group; - Concentration of state efforts on the restructuring of the national economy (policy for the development of new industries, labor-intensive and knowledge-intensive production); - Important mission of the state to collect and communicate to entrepreneurs a large amount of information necessary for successful business.
English or European-Keynesian model	Great Britain, France, Italy	- Presence of a significant scale and share of state property (state property for enterprises of capital-intensive and low-profit industries, whose products significantly affect the level of costs in other industries, especially export); - Implementation of public procurement in large amounts; significant public investment to maintain employment and accomplishment of social tasks.
Market model of new and newly industrialized countries	Republic of Korea, Singapore, Taiwan, Hong Kong, Argentina, Brazil, Mexico, Newly industrialized countries: Malaysia, Thailand, etc.	Asian model - Rapid break-up of patriarchal, feudal structures and the formation of capitalist relations based on the creation of enterprises of the newest high technologies; - Direction of entrepreneurial capital mainly in the manufacturing industry and primary industries; - Creation of labor-intensive enterprises for the production of mass consumer products; - Export-oriented economy; - Great attention is paid to education. Latin American model - Balanced combination of import substitution policy; - Preferential orientation to the external market

Source: Compiled by the author based on [10,15]

Restrictions, international and inter-regional competition, emerging technologies, etc. It is based on a combination of innovation and rational solutions for the use of available resources, as well as the possibility of increasing productivity without compromising the environment and at the same time improving the quality of

life. The model of inclusive development, the rapid growth of income inequality, both in developing and economically developed countries, led to the formation of this model, in which it is necessary to ensure employment and high social standards based on a harmonious combination of high economic growth rates. along with the principles of sustainability. Income inequality poses a threat of social tension and a danger of slowing down economic development.

The recognition by the authorities of many countries that an economy based only on material well-being is no longer efficient has led to an increase in the number of studies aimed at finding other non-material factors that affect the patterns of economic development. It is important to note that, depending on the specific use, social indicators should determine certain properties. Social indicators should reflect a specific social perception, be reliable and meaningful, be sensitive to the main phenomenon, be generalizable, be available in the form of time series, be disaggregated, be understandable and easily interpretable and, if necessary, be linked to other indicators.Conceptualizing the main results of the presented models of economic development, it is worth noting that the main indicators of well-being in the world are: the level of GDP per capita, life expectancy, civil liberties, a sense of security and confidence in the future, family stability, job security, the level of corruption, as well as categories such as trust in society, generosity and generosity. All presented indicators will serve as the information base of the study for the application of multivariate cluster analysis tools.

However, before structuring data for analysis, it is worth considering the economic essence of the concept of "economic indicators". Economic indicators are macroeconomic indicators published in the form of reports by the government or independent organizations and reflecting the state of the national economy. However, each indicator serves a specific purpose and is useful in its own way.The main economic indicators include the following: GDP, inflation, foreign exchange reserves, refinancing rate, public debt, balance of payments, unemployment and a number of monetary indicators. It should be noted that the totality of all presented indices, indicators and indicators is a modern model of economic development. In subsequent years, the Human Development Index, with an expanded interpretation of its constituent elements, began to be considered as the Human Development Index. Based on this, it is worth considering the features of the transformation of key indicators of economic development in the current conditions of volatility and uncertainty, which are presented in Figure 2.

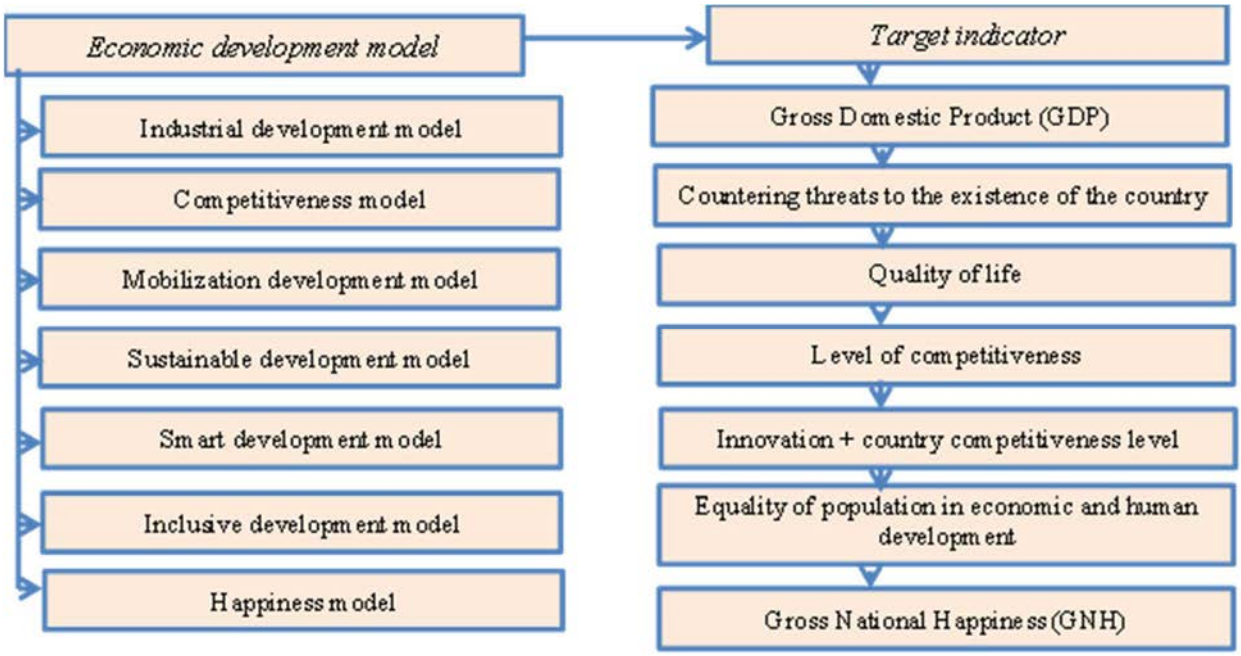

Figure 2 Features of the transformation of key indicators of economic development in the current conditions of volatility and uncertainty
Sources: compiled by the author

To argue and highlight the main results of the study, it is worthwhile to conduct a multidimensional cluster analysis of the main indicators of the economic development of countries. To analyze and determine the main conceptual aspects of the transformation of indicators of economic development of countries in the world, the following indicators have been selected: dynamics of indicators of the global ranking of countries in terms of GDP, GDP per capita, social progress index and the global index of happiness for people in the world. It should be

noted that Gross National Income (GNI) / Gross National Income (GNI) is the total value of all goods and services produced during the year in a state (i.e. gross domestic product, GDP), plus income received by citizens and organizations of countries from abroad, less income taken out of the country by foreign citizens and organizations. One of the key indicators of economic development.

Another important indicator of economic development is the Social Progress Index, a composite indicator of an international research project. The Social Progress Imperative, which measures the achievements of countries around the world in terms of their social development. It is important to note that the relative efficiency with which countries use economic growth and natural resources to ensure the happiness of their citizens is characterized by the Global Happiness Index.

The quality of life is a very real calculated statistical value and, of course, should be expressed in absolute terms and reflect the real spread of the quality of life between developed and underdeveloped countries and contribute to the development of a real policy of the UN and world development institutions to harmonize the dynamics of the global world economy. Urgent and political campaigns are needed to reduce the risks to the global economy and lay the foundations for stable and sustainable economic growth. The dynamism and inclusiveness of the global economy are key to meeting the ambitious targets set by the Sustainable Development Agenda for the coming periods. Policy makers must consider scaling up cases to prevent rising risks of disability, take into account historical and escalating major disputes, and set economic, social and environmental goals as part of a long-term development strategy. Decisive policy visions are based on multi-stakeholder, gathering-based action and are designed to take a long-term approach to global outreach in gatherings such as climate action, sustainable finance, sustainable production and consumption, and addressing inequality. It also requires a move towards a more inclusive, flexible and flexible multi-stakeholder game.

A growing, open and competitive economy is a key means of ensuring continued growth in income and living standards. Without economic growth, the standard of living, or the quality of life that society aspires to, will not improve. Public perceptions of improved welfare have been closely linked to quantitative economic growth for many years. To obtain correct and reliable results of a multidimensional analysis of the economic development of countries, the following theoretical prerequisites are put forward for structuring the countries of the world into clusters according to the following limiting criteria, which are presented in Table 2.

Table 2 Basic limiting criteria for the economic development of countries for multivariate cluster analysis

Economic Development Index	Range of criteria within a cluster	Cluster characteristic
Global ranking of countries and territories of the world in terms of gross domestic product	300-200 billion US dollars	1.Cluster with countries with high gross domestic product
	200-100 billion US dollars	2.Cluster with countries with an average level of gross domestic product
	100-50 billion US dollars	3.Cluster with low gross domestic product countries
World ranking of economies by gross national income per capita	1500-1000 US dollars	1.Cluster with high gross national income countries
	1000-500 US dollars	2.Cluster with countries with average non-gross national income
	500-250 US dollars	3.Cluster with low gross national income countries
Ranking of countries in the level of social development	100-90	1.Cluster with countries with a high level of social development
	90-80	2.Cluster with countries with an average level of social development
	80-70	3.Cluster with low gross of social development
Ranking of happiness countries	50-45	1.Cluster with countries with a high level of happiness
	45-35	2.Cluster with countries with an average level of happiness
	35-30	3.Cluster with low happiness countries

Developed by the author based on the use of tools for multidimensional cluster analysis of the economic development of countries

The main results of the multidimensional analysis of economic development of 25 key countries of the world as of 01.01.2021 are presented in Table. 3. and represent the structuring of countries into clusters according to the level of key indicators.

Table 3 The main results of a multidimensional analysis of the economic development of 25 key countries of the world and their structuring into clusters according to key indicators as of 01.01.2021

Economic Development Index	Cluster by limiting criteria indicators	List of countries of Cluster
Global ranking of countries and territories of the world in terms of gross domestic product	1. High level of GDP	USA, China, Japan
	2. Average level of GDP	Germany, Great Britain, France, India, Italy, Brazil, Canada, Russia, South Korea, Australia, Spain, Mexico.
	3. Low GDP	Indonesia, The Netherlands, Saudi Arabia, Turkey, Switzerland, Poland, Sweden, Belgium, Argentina, Thailand.
World ranking of economies by gross national income per capita	1.High GNP	Liechtenstein, Bermuda, Switzerland, Norway, Macau, Luxembourg,
	2. Average GNP	Iceland, USA, Qatar, Denmark, Ireland, Singapore, Sweden, Australia, The Netherlands.
	3. Low GNP	Hong Kong, Austria, Finland, Germany, Canada, Belgium, Great Britain, Japan, France.
Ranking of countries in the level of social development	1.High level of social development	Norway, Denmark, Switzerland, Finland, Iceland, Sweden.
	2. Average level of social development	New Zealand, Germany, Canada, Japan, The Netherlands, Australia, Great Britain, Ireland, France, Luxembourg, Spain, Portugal, Belgium, Austria.
	3. Low level of social development	Slovenia, Italy, South Korea, Czech, Estonia.
Ranking of happiness countries	1.High happiness	Costa Rica, Mexico, Colombia, Vanuatu, Vietnam, Panama, Nicaragua.
	2. Average happiness	Bangladesh, Thailand, Ecuador, Jamaica, Norway, Albania, Uruguay, Spain, Indonesia, Salvador, Netherlands, Argentina.
	3.Low happiness	Peru, Palestine, Brazil, Switzerland, Tajikistan.

Sources: developed by the author based on data [24]

The main results indicate that in the world global society, countries are divided into 3 main clusters: 1. a high level of economic development and well-being; 2. average level of economic development with prospects for improving the situation; 3. low level of economic development and socio-economic security of the population of the countries.

Based on this, it is worth noting that economic growth can occur without any improvement in well-being, and, conversely, improving the quality of life, without any economic growth, is now increasingly accepted by society in various options and scenarios for economic development. From this point of view, the subjective well-being of a citizen is seen as the ultimate goal of the development of society and, accordingly, the economic development of the state, which ensure the well-being of its citizens and increase prospects. Well-being and quality of life should be subjectively perceived by a person who is the best expert in assessing the quality of his life in terms of subjective well-being. This means that the most important indicators of subjective well-being are in fact the indicators of satisfaction and happiness, which are provided by the effective economic growth of the country and the optimal economic model.

4 Conclusions

In the study, the author highlights the conceptual need to study the features of the economic development of countries in the current conditions of globalization processes. Theoretical aspects of the formation of economic models are considered and the existence of many scientific studies in this area is argued, however, the lack of a single approach to determining the economic essence of the concepts of "sustainable economic development", "economic development" and "economic model" is highlighted. The proposed interpretation of these concepts is based on a critical analysis and generalization of scientific works in this field.

The features of the formation of a model of economic development of countries are considered, their transformation and constant modernization of key indicators of economic development are determined. The author structured the main indicators and models of economic development. It is proved that ensuring the effective functioning of the world economy is impossible without economic growth and constant transformation of economic development models.

The main types of modern economic and economic models are structured, their features and specifics of application in different countries are highlighted. The conceptual necessity of including macro-components in

the country's economic development strategy is argued. The specificity of the transformation of key indicators of economic development of countries is considered, which made it possible to form scientific and methodological aspects of conducting a multidimensional cluster analysis of target indicators of economic development of the countries of the world. The developed scientific and methodological aspects of the multidimensional analysis of the transformation of the target indicators of the economic development of countries made it possible to structure the countries into groups of economic development, taking into account the specifics of their functioning and development strategies.

Three key clusters of countries have been identified and structured according to the level of economic development according to key indicators, namely: 1. high level of economic development and well-being; 2. average level of economic development with the prospect of improving the situation; 3. low level of economic development and socio-economic security of the population of the countries. Based on this, it is worth noting that economic growth can occur without any improvement in well-being, and, conversely, an increase in the quality of life, without any economic growth, is now increasingly accepted by society in various options and scenarios of economic development.

The use of tools of economic and statistical multidimensional cluster analysis of indicators of economic development of the countries of the world in practical activities will ensure the effectiveness of management at the global level.

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ENERGY EFFICIENCY OPTIMIZATION OF LAST MILE SUPPLY SYSTEM WITH REVERSE LOGISTICS CONSIDERATION

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Keywords: energy efficiency, metaheuristic optimization, reverse logistics, last-mile system.
Abstract: Last mile supply system takes great importance in the designed supply chain management, especially in the big urban areas, where various goods delivery locations should be tackled. Transportation routes and vehicles play a critical share in the optimization of the energy spent in this system because it is considered a complicated case due to its high solutions possibilities. Also, part of these transport processes is considered reverse logistics, where the goods take the way back, starting from the customer. Using a metaheuristic optimization is usually a good way to increase operations efficiency and save time and energy, next to raising sustainability. Within this paper, the last mile supply system within urban areas focusing on the goods' delivery and collection tasks is presented. The model design is described, mathematical optimization modelling is detailed, and a case study to investigate the impact of using diesel and electric trucks on energy efficiency is solved. After an introduction and theoretical background that includes a brief literature review, the designed system and used methodology are described. The designed system incorporates cloud computing, real routes of vehicles, analysis of collected data, energy consumption optimization, and time windows. Also, a mathematical model is developed with the aim of optimizing the total energy consumption. Real thirty locations in Budapest in the VII district are described and used as a case study for finding the solutions of the optimized taken routes and energy consumption by the genetic algorithm for both diesel and electric trucks. In the end, the results are analyzed and compared against a random solution to clarify the presented optimization's effectiveness.

1 Introduction and theoretical background

The city logistics area is a rich topic to tackle and research regarding its diverse implementations, especially during recent years because of the numerous various innovations in both transportation and Industry 4.0 areas. The renewable energy evolutions in transport vehicles like e-cars create a wide scope to adopt them in the city logistics applications considering the relatively shorter distances in the city logistics area compared to the outside cities. Moreover, Industry 4.0 applications, which depend on the Internet of Things (IoT) and artificial intelligence, support innovating smart solutions to shorten the required time and road distance while collecting and analyzing information at the same time, giving the capacity to examine them. On the other hand, sustainability is a critical topic that is represented in the Sustainable Development Goals (SDGs), such as the 11th goal, "sustainable cities and communities" [1], which gives it a priority to be tackled in research. The investigation of reducing the spent power, emissions, and contamination aspects was advised to be researched for its positive influence on the climate and environment. Studying these new solutions has significantly raised in many aspects for showing the importance of applying them in reality [2]. Last mile logistics is the latest stage of the supply chain, and it involves a particular share of the overall delivery cost and energy. Industry 4.0 applications allowed the possibility of reducing the time of the order execution within the real-time handling of open tasks in the package delivery service providers' network. Therefore, the last mile logistics optimization shows significant potential for researchers, and it creates a challenge for them [3]. Depending on the energy efficiency's significance of last mile services that are represented by package delivery service providers, it is expressed that this research area is so valuable. The rising value of resources, cost, and power in supply chain applications and the purpose of detecting design and operation strategies enforced in real-time are strong motivations for researching this area [4]. Real-time intelligent scheduling in the last mile delivery was also presented [5] as a developed methodological approach based on the Industry 4.0 applications. Depending on a systemic literature review [4] that was based on 231 articles, more attention and research were required in the last mile supply area, especially with considering the metaheuristic algorithms for energy efficiency aspect. The genetic algorithm (GA) was presented as an effective metaheuristic algorithm in many fields [6], such as operation management, scheduling, and inventory control.

An important aspect of the last mile transportation is reverse logistics (RL) that is one of its definitions is [7] "the process of planning, application, control of the operation, cost and flow of raw materials, the inventory process, finished products, the information related, from the point of consumption to the point of origin, to recover or create value or proper disposal". RL has distinct characteristics, for example, critical uncertainties of time, quality, and quantity supplying next to the operations' complexities. A framework founded on the reverse stream of distribution starting from the producer until the user and backward to the producer was proposed [8]. It defined the motivation types mainly as the economic amount, governance legislation, and ecological image, while disposal kinds were defined as reuse, repair, recycling, and re-manufacturing. Another framework for RL defined five directions: (1) return causes; (2) reception body; (3) product types and their characteristics; (4) recovery operations and settings, and (5) involved actors and their roles [9]. In order to clarify the RL problems and develop solutions, modelling techniques were used [10], but the prime problem is the need for a high number of variables considered. In a study [11], five strategic operators were considered significant for the RL that are environmental concerns, quality, costs, customer service, and political/legal considerations. Also, RL was researched [12] within the composed framework of environmental operators (regulation and environment respect) and business operators (customer satisfaction and returns) [13]. However, a need for further research on the aspects of strategic and organizational frameworks of RL was confirmed [14], which includes integrating the RL in the designed supply system, for instance. Considering RL for sustainable aspect was confirmed [9] as one of the main factors in the city logistics area, particularly from an Industry 4.0 technologies point of view.

The following points sum up the presented theoretical background in the chapter:

- Last mile transportation operations are a rich area to research considering its various application and tools to be adopted especially considering the innovative Industry 4.0 technologies and applications.
- While RL takes a primary share of the transportation applications in city logistics, it still requires more research to investigate its results and effects.
- Using metaheuristic optimization is considered an effective method to optimize the last mile transportation processes. The GA showed strong optimization results in many areas including the logistics area. Also using the direct lines (not real) distances between the location is a common way to be used in previous research.
- Electric vehicles showed promising leverage for raising energy efficiency. However, further research on this adoption and its effects is required to find out deeper outcomes.

2 System description and methodology

The last mile transportation system expresses the operations that take place under the city logistics aspect. While the goods storage station represents the last echelon of where the goods are to be delivered to the specified locations, RL also happens to be collected from specified locations to be moved to the goods storage station. This system is represented as a scheme in Figure 1. Routes and consumed time are calculated depending on Open Route Service, which gives real distances and time. This service was developed by HeiGIT gGmbH [15].

The locations express both types of goods' delivery and collection. It shows how RL operations were integrated into the supply system. Cyber management expresses the cloud system where the data are stored, analyzed, and calculated. Therefore, information flow is considered between the cyber management and IoT tools within the system parts, such as the trucks and goods storage station GA is used in this system to calculate the optimized energy efficiency solutions for doing the goods' delivery/collection. However, in this study, an upgrade step is used regarding the iteration number. Instead of raising the iteration number to reach better results, three runs are done, and the best value will be selected as the optimized result. The optimization is represented in Figure 2 next to the used locations' order coding for two trucks case that is applied in the case study of this article. After the separation of the two trucks' location orders, the locations will be reordered separately, considering that location 0 is the start and end location for both trucks. Therefore, the last location is transferred into 0 after separating the two locations' orders. This process is illustrated in Figure 2, which is more detailed in mathematical modelling.

ENERGY EFFICIENCY OPTIMIZATION OF LAST MILE SUPPLY SYSTEM WITH REVERSE LOGISTICS CONSIDERATION

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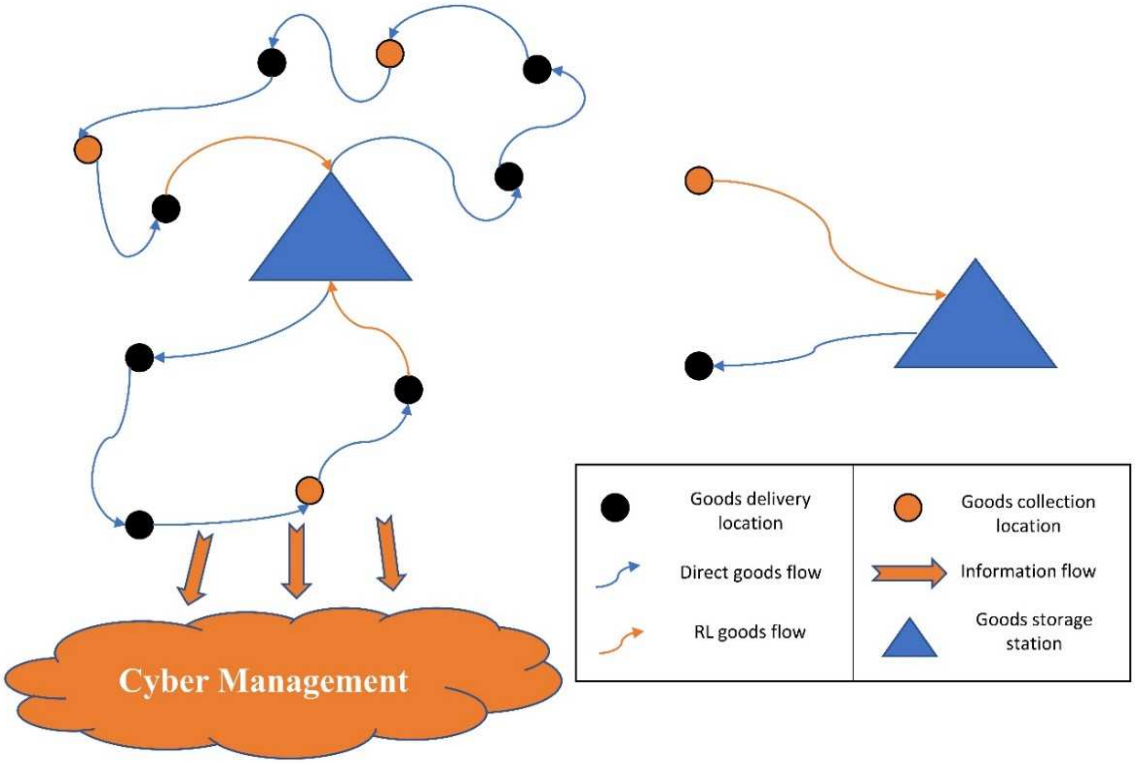

Figure 1 Last mile supply system scheme

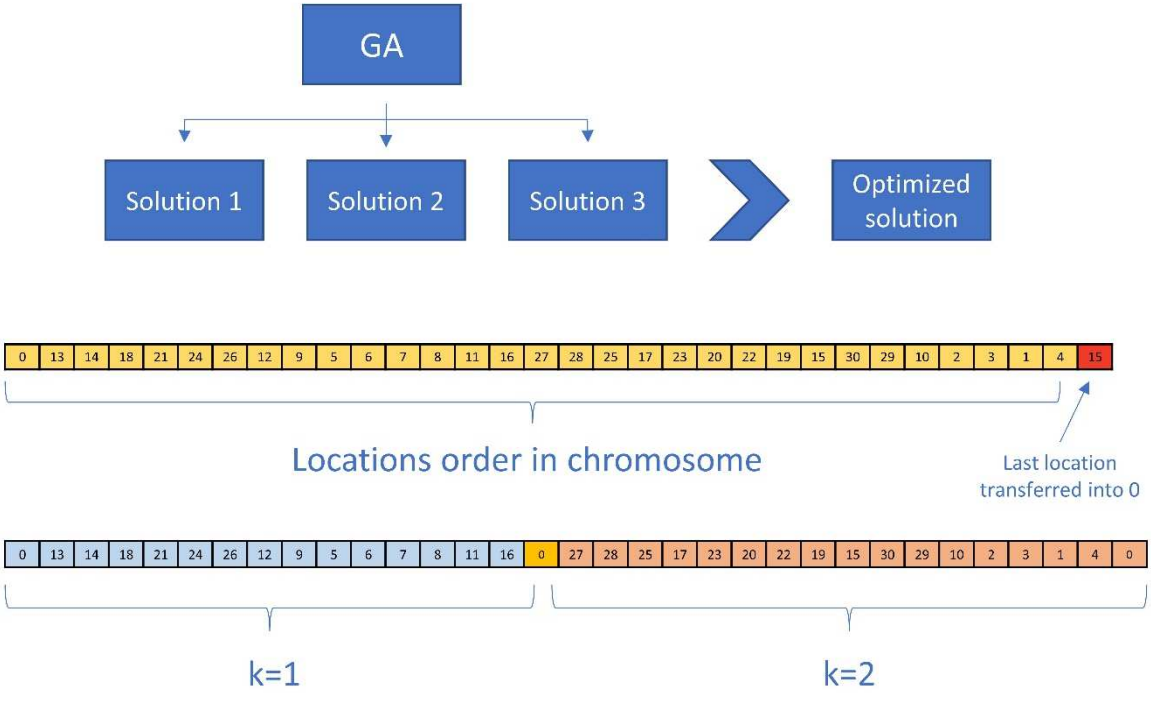

Figure 2 GA optimization methodology

This chapter presented the designed system and methodology. Chapter three details the mathematical modeling of this system to optimize energy efficiency. Chapter four presents a validation for the mathematical modeling for 30 locations in VII District in Budapest by using diesel and electric trucks. A random solution is to be

used to compare the optimization efficiency. Chapter five discusses the results and expresses the possible further research directions. Finally, a summary that sums up this study. This scientific contribution that defines the aim of this paper is summarized in the following points:

1. Designing last mile goods transportation system with integrated RL operations. This system considers incorporated Industry 4.0 technologies such as IoT and cloud data analysis.
2. Presenting an elaborated description for the mathematical model depending on the efficiency of the spent energy and designed system. It is important to mention that part of the mathematical model is adopted from previous research [16] while the parts are developed within this study.
3. Employing the actual routes method between locations in city logistics applications instead of the conventional direct lines to achieve realistic results. Also, a case study of 30 locations in VII District in Budapest is discussed and analyzed.
4. Finding the optimized energy consumption by using the actual real routes by GA algorithm for both diesel and electric trucks with a clear comparison and discussion with a considering for a random solution. Moreover, GA optimized solution was updated with an explanation of the used coding system.

3 Mathematical modelling

In the vehicle routing problem (VRP), it is worked on finding the shortest travel distance roads with starting in and returning to the same place for serving a group of customers [17]. The VRP has been applied in various applications, including but not bounded to city logistics goods' delivery and collection.

However, there is a second way where a few researchers considered the goods' delivery/collection problem to be an arc routing problem (ARP) instead of the VRP which is called a node routing problem. The prime variance between ARP and VRP is that the concentration goes on the routes instead of nodes in the ARP because the vehicles carry out their provided services whilst traversing the routes. Therefore, the goods' delivery problem considers the clients are located over the roads, from an arc point of view not at the nodes. Overall, because there is a specific set of locations that should be serviced in this study; hence, the VRP model was selected. Furthermore, in particular situations, the tackled locations' density over a specific street is very big that the better approach for solving the routing problem is the ARP instead of the VRP [18]. Such situations do not appear in this study, as the locations are somehow scattered around the city center. Also, the CVRP is considered as an adoption of the VRP while applying capacity constraints. The CVRP in our mentioned system is identified as goods delivery and collection from and to a group of locations using homogeneous trucks that have a specified capacity, which is not possible to be violated; each one of these trucks starts from and returns to a specific same location [19]. The used model of this study is detailed in this chapter, where n is the visited locations' number and m is the used trucks' number by homogeneous trucks that are defined as $K = \{1, 2, \dots, m\}$, the mentioned trucks are stationed at the goods storage station at the beginning. The index set $I = \{0,1,2, \dots, n\}$ refers to the locations where $i, j \in I$. $i = 0$ refers to the goods storage station location. For each location, there is q_i goods' quantity that should be delivered/collected. The positive value refers to the delivery task, while the negative value refers to the collection task. D_{ij} refers to the real road distance from location i to location j, where $i \neq j$, and it should have a non-negative value.

The model of this study considers the capacity of both the trucks and the goods, where:

- C refers to the maximum goods' amount that is possible for the trucks to transport.
- q_{max} refers to the maximum goods' amount in each location that is possible to be tackled.

Additionally, the model presents a time limit as well, where:

- T_{max} refers to the maximum specified time for the whole process.
- t_k refers to the time that is taken by truck k to finish its route and go back to the start location.

The total energy consumption (TE) is the defined objective function where it aims to be minimized. It refers to the spent kWh by the used trucks during the goods delivery/collection system, which is found depending on the distance length, and specific fuel consumption rate [2]. The following mathematical modeling is based on previous research [16] that tackled a waste management system. Within this study, the previous model was adopted and developed to tackle the described system in chapter two. This modeling has two decision variables. X_{ijk} that is 1 if vehicle k proceeds from location i to location j; otherwise, it is 0. Y_{ik} that is 1 if location i is part of the vehicle k route; otherwise, it is 0.

The objective function is described as:

$$\text{TE} = \sum_{k=1}^{m} \sum_{i=0}^{n} \sum_{j=1}^{n} X_{ijk}.Dij.c_{ijk}^{T} \rightarrow min \quad (1)$$

where D_{ij} is the real distance from location i to location j, X_{ijk} is the decision variable, k is the number of trucks, and c_{ijk}^{T} refers to the specific fuel consumption that is defined as

$$c_{i,j,k}^{T} = c_{kmin}^{T} + ((c_{kmax}^{T} - c_{kmin}^{T})/c_{kmax}^{T}) q_{ijk} / ((q_{ijk}/c_{kmax}^{T}) + C - q_{ijk}) \quad (2)$$

where c_{kmin}^{T} and c_{kmax}^{T} refer to the lower and upper bounds within the specific fuel consumption depending on the weight of the goods, and q_{ijk} represents the weight of the

goods picked up by truck k when moving from location i to location j.

Subject to the following constraints:

$$\sum_{i=0}^{n}\sum_{k=1}^{m} X_{ijk} = 1 \ \forall j \in \mathrm{I} \quad (3)$$

$$\sum_{j=1}^{n} X_{ijk} = \sum_{j=1}^{n} X_{jik} = Y_{ik} \ \forall i \in I;\ k \in K \quad (4)$$

$$\sum_{i=0}^{n}\sum_{k=1}^{m} q_{jik} - \sum_{i=0}^{n}\sum_{k=1}^{m} q_{ijk} = c_j \ \forall j \in I \quad (5)$$

$$\sum_{i=1}^{n} c_i X_{ijk} \leq C \ \forall j \in I;\ k \in K \quad (6)$$

$$\sum_{i=1}^{n}\sum_{k=1}^{m} X_{i0k} = 1 \quad (7)$$

$$\sum_{i=1}^{n} q_i \leq \sum_{k=1}^{m} C_k \quad (8)$$

$$max(t_1, t_2, \dots t_m) < T_{max} \quad (9)$$

Equation (3) ensures that only one vehicle visits every location. Equation (4) states the condition of continuity. Equation (5) states that the truck does deliver/collect the goods at the visited location. Equation (6) states that the carried goods within the tour should not overrun the capacity of the vehicle. After the last location is visited, the truck returns to the goods storage station according to equation (7). Equation (8) ensures that the total goods' weight for the allocated locations is less than the overall capacity of used trucks. Equation (9) states that the taken time by each truck does not exceed the allocated time for the process. Used notations are illustrated in Table 1.

Table 1 Used notations

Notation	Description
n	Visited locations overall number.
m	Trucks overall number.
K	The indices group represents trucks.
I	The indices group represents visited locations.
$i, j \in I$	Two arbitrary indices denote a visited location.
$k \in K$	An arbitrary index of a truck.
q_i	A value representing the goods weight of location i.
q_{ijk}	A non-negative amount represents the goods' weight in truck k while moving from location i to location j.
C	The truck's maximum capacity of goods.
T_{max}	The specified maximum time to finish the entire process.
t_k	The time that is taken by truck k to finish its route and go back to the start location.
q_{max}	The maximum goods' capacity in each location is to be tackled.
X_{ijk}	A decision variable that is 1 if vehicle k proceeds from location i to location j otherwise, it is 0.
Y_{ik}	A decision variable that is 1 if location i is part of vehicle k route, otherwise, it is 0.
TE	Total optimized energy consumption.
c_{ijk}^{T}	The specific fuel consumption for truck k when moving from location i.
c_{kmin}^{T}	Specific fuel consumption's lower bound.
c_{kmax}^{T}	Specific fuel consumption's upper bound.

4 A case study in Budapest

For validating the presented mathematical model, a case study that consists of thirty locations in the VII District in Budapest is described and analyzed. The actual real routes are used to find the total optimized energy consumption of the used trucks in kWh by using the GA metaheuristic algorithm. The solutions are to be compared against a random solution for each case to outline the optimization efficiency. Within this case, the lower and upper bounds of specific fuel consumption are considered the same as in a previous study [2] while assuming an average speed of 25 km/h in the city center. The time window is an essential consideration since there is interaction with customers, moreover, electric trucks have limited operational time usually depending on their battery capacity. Used truck specifications are presented in Table 2.

Table 2 Used truck specifications

	c_{kmin}^{T}	c_{kmax}^{T}	q_{max}	C	T_{max}
Diesel	20 kWh/km	41 kWh/km	100 kg	600 kg	3 hours
Electrical	11 kWh/km	18 kWh/km	100 kg	500 kg	2 hours

For obtaining the locations' data, a generating method was used [16]. Two geographical locations were chosen as geographical boundaries to find the locations' data in the VII District in Budapest. The Haversine formula was used to calculate the diameter depending on the distance between those two selected locations. Additionally, a circle was shaped depending on the calculation of the centric location over the segment amidst the two boundaries. Then, the locations were generated in the circle boundary in a random way using a uniform distribution. After that, the

ENERGY EFFICIENCY OPTIMIZATION OF LAST MILE SUPPLY SYSTEM WITH REVERSE LOGISTICS CONSIDERATION

Mohammad Zaher Akkad; Rana Rabee; Tamas Banyai

generated locations were ensured that they represent convenient locations on the map, and a few of them were manually adjusted. The goods' weight in every location was generated following a uniform distribution in a random way as well. Table 3 shows the goods' weight and their locations.

Table 3 The goods' weight and their locations

ID	Latitude	Longitude	Goods' weight (kg)
0	47.501374	19.093158	-
1	47.497593	19.055899	33
2	47.498133	19.057511	-9
3	47.497602	19.058477	74
4	47.496396	19.059368	88
5	47.497686	19.060825	-68
6	47.498425	19.061217	67
7	47.500001	19.059982	71
8	47.499277	19.064749	-17
9	47.497431	19.067606	1
10	47.49691	19.068347	20
11	47.498606	19.069738	52
12	47.498354	19.073727	-40
13	47.499479	19.074273	29
14	47.500382	19.073401	-18
15	47.504214	19.074972	19
16	47.502627	19.080453	8
17	47.502982	19.081409	-40
18	47.505488	19.082116	61
19	47.507706	19.081259	37
20	47.509121	19.081838	-17
21	47.508908	19.083005	81
22	47.508367	19.083632	52
23	47.50606	19.084608	76
24	47.504937	19.085591	-14
25	47.503217	19.08456	43
26	47.50247	19.08532	50
27	47.504233	19.087563	-39
28	47.503577	19.088435	39
29	47.501554	19.065602	-40
30	47.50562	19.069682	40

For implementing the GA, the following parameters were considered: population size is 100, the crossover probability is 40%, mutation probability is 20%, the number of iterations is 100, and the selection method is tournament selection. The utilized machine has an i7-7500U 2.70 GHz processor, and 8 GB of RAM.

4.1 The first case of diesel trucks

In this case, two trucks were needed. Total consumed energy, total distance, needed time for the process, and initial weights for each truck, in this case, are summarized in Table 4. Execution of the whole code is 14.62 s. Also, the total energy and distance for a random solution are mentioned.

Figures 3 and 4 show the actual routes for the optimized solution and random solution of this case. Red and blue colors are used to distinguish each truck's route.

Table 4 Results of diesel trucks case

	Total energy (kWh)	Total distance (km)	Time (min)	Initial weight (Truck 1)	Initial weight (Truck 2)
Solution 1	606.17698	29.24704	50.06	105	197
Solution 2	**534.2343**	**25.94166**	**39.331**	**152**	**150**
Solution 3	548.88179	26.33791	43.3312	157	145
Optimized solution	**534.2343**	**25.94166**	**39.331**	**152**	**150**
Random solution	1429.40629	66.1656	-	-	-

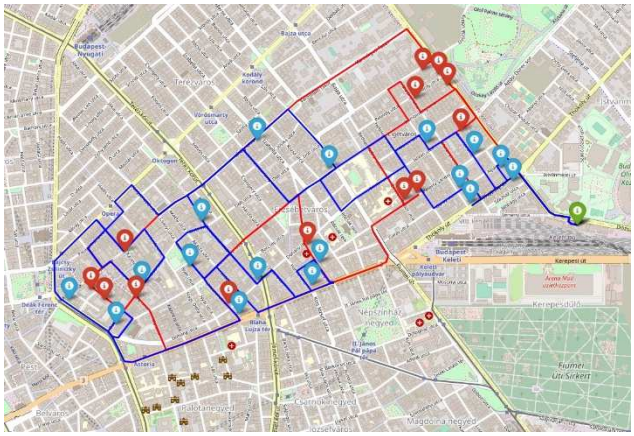

Figure 3 Optimized solution for the first case (diesel)

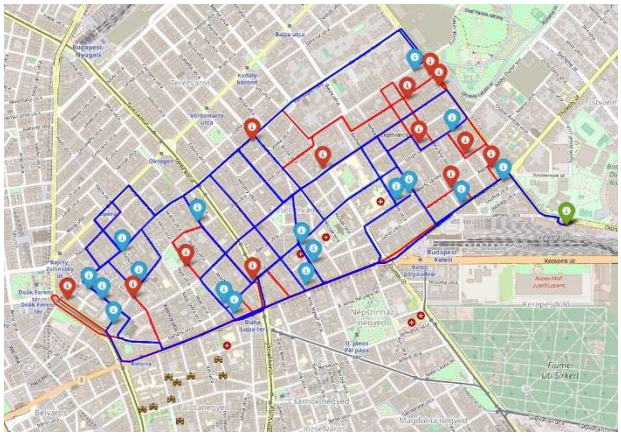

Figure 4 Random solution for the first case (diesel)

4.2 The second case of electric trucks

In this case, two trucks were needed as well. Total consumed energy, total distance, needed time for the process, and initial weights for each truck are presented in Table 5. Execution of the whole code is 13.95 s. Also, the total energy and distance for a random solution are mentioned.

Figures 5 and 6 show the actual routes for the optimized solution and random solution of this case. Red and blue colors are used to distinguish each truck's route.

Table 5 Results of electric trucks case

	Total energy (kWh)	Total distance (km)	Time (min)	Initial weight (Truck 1)	Initial weight (Truck 2)
Solution 1	**289.8513**	**24.7695**	**45.7**	**217**	**85**
Solution 2	326.82914	28.42226	42.4	187	115
Solution 3	298.91565	25.31579	39.8	208	94
Optimized solution	**289.8513**	**24.7695**	**45.7**	**217**	**85**
Random solution	707.68439	59.83013	-	-	-

Figure 5 Optimized solution for the second case (electric)

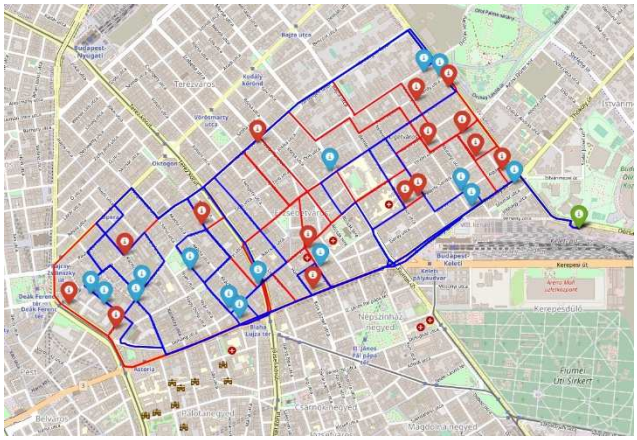

Figure 6 Random solution for the second case (electric)

5 Discussion and further research

The results showed a big difference between the optimized and random solutions. The random solutions in Figures 4 and 6 showed numerous overlaps in the selected routes, which explains why there is a raise in their results compared with the optimized solutions. Figures 7 and 8 express the differences for calculated total energy and distance where OS refers to the optimized solution and RS refers to the random solution.

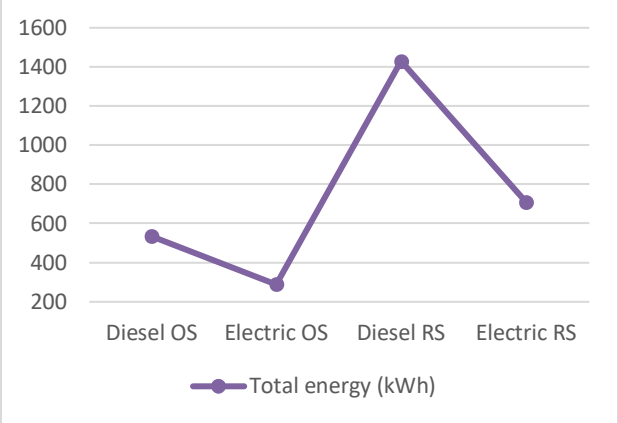

Figure 7 Calculated total energy

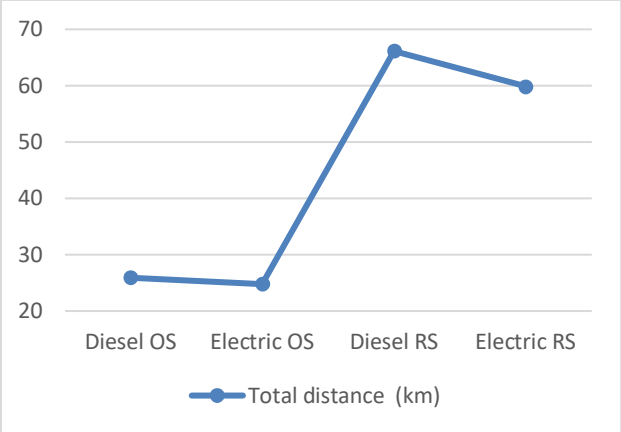

Figure 8 Calculated total distance

The results express two aspects to be compared. The first is the optimization efficiency of GA with the random solution comparison. The results expressed minimizing the total energy as 37.3% and 40.95 % compared to the random solution for diesel and electric cases respectively. Also, the results expressed minimizing the total distance as 39.2%

and 41.4 % compared to the random solution for diesel and electric cases respectively. Second, comparing the diesel and electric cases efficiency. The results expressed minimizing the total energy as 54.26% in the electric case compared to the diesel one. However, in the total distance, the results were very similar.

GA algorithm showed high efficient results in the optimization of this case, especially considering the applied upgrade where 3 solutions were done at the beginning to have a higher chance to exclude any possible local minimum points. The execution time is relatively acceptable since it will be done before the beginning of the process. However, even with conceding real-time updates, new runs to calculate updated routes are possible considering that it takes about around 15 seconds to reach the results for 30 location cases. The electric trucks showed a very positive impact on energy reduction, which supports adopting them widely in reality. However, possible challenges to this adoption may happen, therefore, analyzing real-life cases of electric truck use is interesting to find out the accrued trouble. The designed system tackled the last mile supply system, RL operations in city logistics, analysis of collected data, vehicles' actual real routes, energy optimization, and time window. By using actual real routes, further realistic and practical results were ensured.

Possible further research on this topic is recommended in three directions. The first direction, calculating accrued emissions since the emissions reflect directly on the sustainability aspect with considering the expected footprint difference between the electric and diesel truck. The second direction, since the optimization process does not have a limit to stop at, refinements in the presented mathematical model and the used GA algorithm structure are possible to be researched. Also, using hybrid algorithms is possible to be investigated as they showed promising outcomes in different cases [20]. The third direction, analyzing real-life case studies that use electrical trucks takes special importance as it is possible to analyze and find out unexpected problems.

6 Conclusion

Within this paper, last mile supply system within urban areas with a focus on the goods' delivery and collection tasks was presented. The model design was described, optimization mathematical modeling was detailed, and a case study to investigate the impact of using diesel and electric trucks on energy efficiency was solved. After an introduction and theoretical background that included a brief literature review, the designed system and used methodology were described. The designed system incorporated cloud computing, real routes of vehicles, analysis of collected data, energy consumption optimization, and time windows. Also, a mathematical model was developed with the aim of optimizing the total energy consumption. Real thirty locations in Budapest in the VII district were described and used as a case study for finding the solutions of the optimized taken routes and energy consumption by the genetic algorithm for both diesel and electric trucks. In the end, the results were analyzed and compared against a random solution to clarify the presented optimization's effectiveness.

The results expressed two aspects. First, regarding the optimization efficiency of GA with the random solution, results expressed minimizing the total energy as 37.3% and 40.95 % compared to the random solution for diesel and electric cases respectively. Also, the results expressed minimizing the total distance as 39.2% and 41.4 % compared to the random solution for diesel and electric cases respectively. Second, regarding the diesel and electric trucks' efficiency, the results expressed minimizing the total energy as 54.26% in the electric case compared to the diesel one. However, in the total distance, the results were very similar.

Depending on the achieved results, the authors recommend the adoption of electric trucks in the city center for their positive impact on the environment by saving spent energy. Also, optimization is widely used in transportation and logistics, however, raising the efficiency of the used optimization method next to widen the tackled data like including reverse logistics in the tackled system is highly recommended. This study's limitations include the following: first, using a single objective function while there is a possibility to use multi objectives optimization that would make the model more complicated but with further details and consideration for reality. Second, GA has many parameters to be specified while there is a possibility for more efficient parameters including the iteration number. Third, assumptions with average numbers were used to analyze the trucks' tasks. It is possible to use other types of trucks with more detailed specifications. Fourth, while the case study in this paper counted on real locations in Budapest, many assumptions and considerations were used as well. Finding a real case where electric trucks are used would be interesting to collect and analyze real data regarding the trucks and goods.

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IMPACT ANALYSIS OF URBAN FREIGHT TRIPS GENERATED FROM WHOLESALE MARKET, AHMEDABAD

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Keywords: freight trip attraction, freight trip production, freight transportation, SPSS, wholesale market.
Abstract: Freight transport plays an important role in meeting the domestic needs of the city's inhabitants. But when freight vehicles come into contact with city traffic, it has a negative impact on urban routes, such as extra traffic congestion, noise pollution, air pollution, etc. The aim of the study is to assess the impact of freight transport on the overall traffic of the city. A case study of the wholesale market of Ahmedabad has been considered as a study area. The freight trip models based on the trips attracted and produced by the market are developed on the basis of data collected from establishment surveys and freight vehicle driver surveys. Both the models developed in this study, FTA (Freight Trip Attraction) and FTP (Freight Trip Production), have R Square values of 0.799 and 0.715, respectively. The volume of freight vehicles contributing to the overall traffic flow is also measured by the traffic volume study. Through the data analysis and identification of the impact of freight transportation on city traffic, remedial measures are discussed to reduce the impact of freight transportation.

1 Introduction

The development of the transport system is essential for the economic development of the country. For this, the movement of passengers and goods should be safe and efficient. Along with the movement of passenger traffic, the movement of goods on the road network is equally important in both urban and rural areas. Society cannot sustain economic development without the smooth movement of the freight transport system. Due to the changing lifestyles of our society and technological advancement, there is a possibility of significant growth in freight transport in the future. However, it also has a negative effect on our daily lives, such as traffic noise on urban routes, air pollution, and creating additional traffic congestion. The movement of goods within a town or city generates a substantial demand for road space and parking facilities. According to MORDOR Intelligence [1], the transport industry contributes about 6.3% of the GDP and is dominated by the road sector. More than 50% of freight and 90% of passenger traffic is controlled by roads. According to the Road Transport Yearbook 2018-2019 by MORTH [2], the total number of transport vehicles has increased from 23.97 million in 2017-18 to 25.89 million in 2018-19. The newly registered transport vehicles in 2018-19 is shown in Figure 1. From the study, actual freight transport patterns and modes of freight transportation used in the market can be identified, new guidelines for improvement and necessary policy changes can be made [3]. The study helps in urban planning and the development of a framework for sustainable freight transportation. The objectives of this study are to develop a model for measuring the number of trips produced and attracted by the market; the impact of freight vehicles on the overall market traffic is analyzed, and remedial measures are suggested to reduce the impact.

The study was carried out at Gheekanta wholesale market, Ahmedabad a city in India. The multilinear model was developed in this study to estimate freight trip attraction and production by market. An establishment survey and a freight vehicle driver's survey were carried out in the market to collect data. The number of freight trips attracted by the market depended on the quantity of goods arriving in the shop in a day, the average floor area of the shop, and the distance between the origin and destination of the trip. The amount of freight produced by the market depended on the distance between the origin and destination of the market and the number of employees in the shop [4-5].

The paper consists of six sections, i.e., Introduction, Literature Review, Study Area, Methodology, Data Analysis, and Results, Conclusions. Introduction sections provide general information about freight transport and its negative effects. The literature review highlights past studies on freight transport. The study area sections provide general information about the Gheekanta wholesale market, Ahmedabad. In Methodology, the steps for conducting the study is given. In this study, an establishment survey, a freight vehicle driver survey, and a

traffic volume study were conducted. In the Data Analysis and Results section, multiple linear regression is used to estimate the trips attracted and produced by the market. As well as the amount of freight traffic in the total market traffic is analyzed. And market parking conditions are also analysed. After the analysis section, the findings of the study and recommendations for improvement are given.

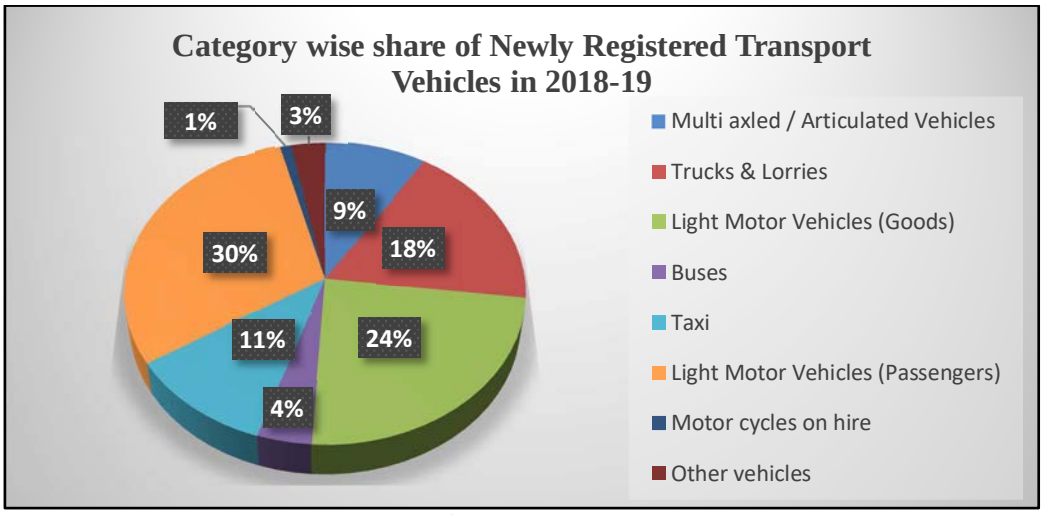


Figure 1 Category wise share of newly registered transport vehicles in 2018-19

2 Literature review

Bhavesh Dhonde (2021) [6], This paper presents a review of urban freight studies carried out for different cities in India. The purpose of this paper is to identify and analyse the factors inhibiting research on urban freight transport in developing countries like India. From the study, it is found that the number of services or commodities considered for the study considerably affects the methods of freight research and that, to study the overall impact of urban freight transportation on city traffic, all the goods and services that generate freight trips need to be considered. But the study on specific commodities or services gives reasonably good results and also reduces the cost of the data collection. Establishment surveys, freight transport operators' surveys, and secondary data are the most preferred methods for data collection in developing countries.

Agnivesh Pani and Prasanta K. Sahu (2019) [7], This paper analyses the non-response behaviour in freight surveys. The study was carried out in Kerala, India by conducting an establishment-based freight survey (EBFS). The aim of the research is to enhance the current knowledge about the concerning patterns in non-responsiveness. Results of the study show that the industrial classes handling commodities with high-value density exhibit a high non-response probability for freight surveys. This may be due to the fact that establishments handling high-value products tend to be less attentive to logistics strategies or have higher capital and opportunity costs associated with these commodities, and therefore, their information tends to be more proprietary in nature. The results also show that the location of the establishment also affects non-response behavior. Establishments near ports with a high per capita income are less likely to respond to the survey.

Khalid Aljohani and Russell G. Thompson (2016) [8], This paper represents the literature review of the various impacts of logistics sprawl, providing a detailed taxonomy. Not only does the location of logistic facilities affect urban goods movement, but it also has an impact on the urban environment. Paper represents the main two factors that contribute to the relocation of logistics facilities. The first is land use, and the second factor is new operational and location requirements. The paper mentions the impacts of logistics sprawl, such as the impact on urban freight geography. increased distance travelled by trucks and it creates negative impacts on the environment.

Bhavesh Dhonde and Chetan R. Patel (2021) [9], The study aims to assess the impacts of the city's geographic sprawl on urban freight transport in the Surat textile industry. An establishment survey was conducted at weaving units in various textile manufacturing clusters in the city. Trips are calculated based on the factors affecting trip generation for which a multi-linear regression model was developed. The total number of trips generated depends on the total number of weaving machines, the total floor area, the total number of employees at the unit, and the type and capacity of the vehicle used for transportation.

3 Study area

The Gheekanta wholesale market, Ahmedabad is taken as the study area (Figure 2). Gheekanta is the wholesale market for readymade garments. There are about 1000 shops in the market. The market acts as a distribution

centre. Readymade garments come into the market and are sold at wholesale prices after packing and labelling. This market receives goods (textiles) from Ahmedabad as well as states like Delhi, Mumbai, and Rajasthan. These goods are sold in Ahmedabad, Gujarat, and all over India. The market opens between 10 and 11 a.m. and closes between 7 and 8 p.m. the market is very old, the streets are narrow, about 7-8 m. Therefore, large freight vehicles like Light Commertial vehicles (LCVs) and Heavy commertial vehicles (HCVs) cannot enter the market. Small commercial vehicles are used to transport goods such as three-wheeler rickshaws, three-wheeled bicycles, and two-wheelers.

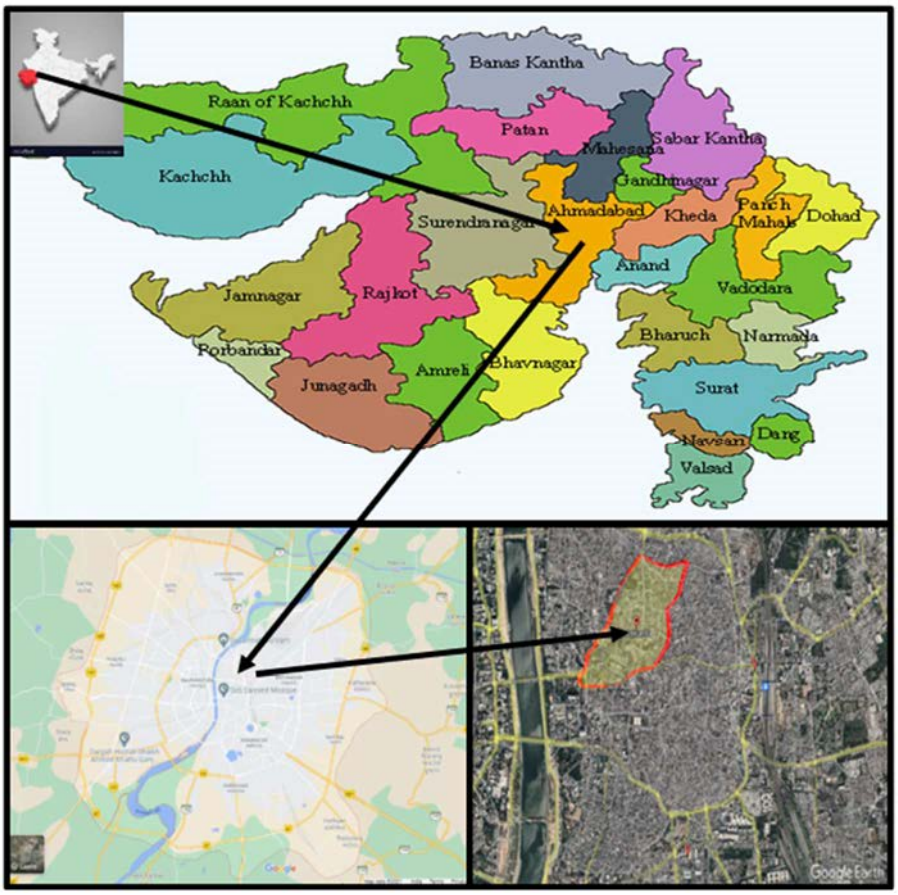


Figure 2 location of Gheekanta market

4 Methodology

The proposed methodology involves various steps to achieve the aim of the study. First, the problem is identified, and the need for the study is also identified. The aim and objective of the study are selected. Studies carried out in the past according to the study topic are found and studied. Data collection needs to be carried out in the study area. In terms of data collection, three surveys are planned for the study. The first is the establishment survey. In the establishment survey, a survey form is made to get information about the shops in the market. How many quantities of garments are coming and going from each shop in the market is also found out. The form can also provide information about the workers working in the shop and the owner, e.g., where workers and owners come from and which mode of transport they use and where they park their vehicles if private vehicles are used to come to the market. The second survey is the freight vehicle driver's survey. The survey provides information about where goods come from in the market and where they go from the market. It also gives information about the parking facilities for loading and unloading of goods in the market. The third is the traffic volume survey, which gives the number of vehicles coming and going from the market in a day. It is carried out at six different location as shown in Figure 3. After the data collection, this data needs to be analyzed. The supply chain process of the market, the multi-linear regression model to estimate freight trips attracted and produced by the market, and the goods loading and unloading scenarios in the market are understood in the data analysis stage. From the above data analysis, the effect of freight traffic on other traffic in the market is derived. From the result, the conclusion will be carried out, and suitable recommendations will also be provided to improve the condition of traffic.

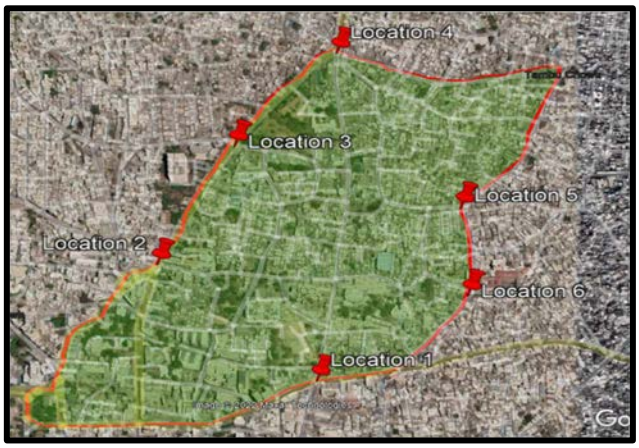


Figure 3 Survey location for traffic volume study

5 Data analysis and result

5.1 Supply chain process of market

The market works like a distribution unit. In this market, ready-made garments are labelled, packaged, and sold to other customers at wholesale prices. The supply chain process of the market shown in Figure 4. The garments coming into the market mainly come from other states like Delhi, Mumbai, Rajasthan, etc. and Ahmedabad based textile companies. Garments that come from other states are transported to Ahmedabad by train or bus, which are procured by the local transport offices and then taken to the market by rickshaw or pedal rickshaw. These transport officers are mainly located at Kalupur, Raipur, Madhupura, Premdarwaja, Saranpur, etc. And the clothes that are made by the textile company in Ahmedabad are taken to the market with the help of rickshaws or pedal rickshaws from the company. Similarly, the garments sold in the market are transported by rickshaw or pedal rickshaw if they are sold in Ahmedabad. If it is sold in other states like South India, Maharashtra, Kolkata, Madhya Pradesh, etc., then the goods are delivered to the transport office by rickshaw or pedal rickshaw, and from there the goods are transported by train and bus.

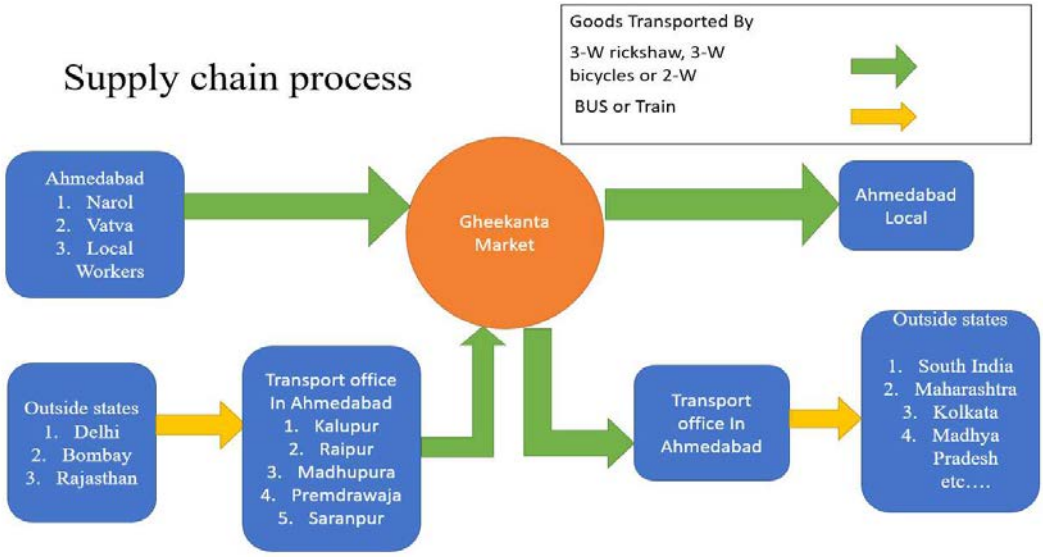


Figure 4: Supply chain process of Gheekanta market, Ahmedabad

5.2 Estimation of freight trips from Gheekanta market

Establishment survey data is used to estimate the freight trips generated and attracted by the market. Multi-linear regression (MLR) models have been developed to estimate freight trip generation and attraction.

5.2.1 Freight trip attraction model

The freight trip attracted by any shop mainly depends on the quantity of goods arriving, the floor area of the shop, and the distance between the shop and the transport office. Therefore, for this FTA model (freight trip attraction), the trips attracted by any shop are treated as a dependent variable, and the quantity of goods arriving in the shop, the floor area of the shop, and the distance between the shop and the transport office are treated as independent variables. The correlation between these dependent and independent variables is given in Table 1.

Freight Trip Attraction Model

$$FTA = 2.5136 + 1.206\,(Q) + .0176\,(A) - 0.2191\,(D) \quad (1)$$

Where:

FTA is the Freight trip attracted by any shop in the Gheekanta market.

Q is the Quantity of goods arriving in the shop in a day (numbers in thousands).

A is the average floor area of the shop (in square meter).

D is distance from the Origin of the trip (transport offices) to the Gheekanta market (in km).

Table 1 Correlation matrix for freight trip attraction model

	Trip Attracted by shop	Quantity of goods Coming in shops (In number)	Avg. Area of shops (m^2)	Distance between transport office and market (km)
Trip Attracted by shop	1			
Quantity of goods Coming in shops	0.303*	1		
Avg. Area of shops	0.386**	0.337**	1	
Distance between transport office and market	-0.794**	-0.097	-0.223	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Pearson correlation between dependent and independent variables was found to be moderate positive/Negative correlation and statistically significant ***(P <0.05)***.

The statistical parameters for the FTA model are given in Table 2. The table shows that the significance F value and P-values are less than the critical values (0.05). which indicates that the model can significantly predict the number of trips.

Table 2 Statistical parameters of FTA model.

	Coefficients	Standard Error	t Stat	P-value	F	Significance F	R Square
Intercept	2.513	0.296	8.475	8.62E-12	46.876	1.26E-15	0.704
Quantity of goods coming to shop	1.205	0.512	2.353	0.022			
Avg. Area in meter	0.017	0.008	2.102	0.040			
Distance from shop to market	-0.219	0.021	-10.204	1.20E-14			

The model has an R Square value is 0.704, which indicates that the model explains 70.4% of the variance in the dependent variable. The model equation also explains the positive relationship between the quantity of goods arriving in the shops and the average floor area. This means that if the shop has more floor area, they order more goods, and the number of trips increases as all the goods are transported by 3-rickshaw or pedal rickshaw. There is a negative correlation between freight trips and distance, which means that for longer distances, more time is required, and because of delays caused by traffic, drivers make fewer trips than short-distance deliveries.

5.2.2 Freight trip production model

The freight trip produced by any shop depends on the number of employees in the shop and the distance between the market and the transport office. For the FTP model, the trip produced by any shop depends on the number of employees working in the shop and the distance between the market and the transport office. The correlation between these dependent and independent variables is given in Table 3.

Freight Trip Production model

$$FTP = 2.5114 - 0.5497\,(D) + 0.5056\,(E) \quad (2)$$

Where:
FTP is the freight trip produced by the shop in Gheekanta market.
D is the distance between market and transport office (in km).
E is the number of employees in the shop (in numbers).

Table 3: Correlation matrix for freight trip production model

	Trip produce by shops	Distance from shop to transport office (km)	No. of employee working in shop (in numbers)
Trip produce by shops	1		
Distance from shop to transport office	-0.756**	1	
No. of employee working in shop	0.722**	-0.528**	1

Pearson correlation between dependent and independent variables was found to be moderate positive/Negative correlation and statistically significant ***(P <0.001)***.

The statistical parameters for the FTA model are given in Table 4. The table shows that the significance F value and P-values are less than the critical values (0.05). which indicates that the model can significantly predict the number of trips.

Table 4 Statistical Parameters of FTP model

	Coefficients	Standard Error	t Stat	P-value	F	Significance F	R Square
Intercept	2.511	0.441	5.690	1.19E-06	51.557	6.43E-12	0.715
Distance	-0.549	0.103	-5.299	4.27E-06			
Employee	0.505	0.110	4.558	4.58E-05			

The model's R Square value is 0.715, which indicates that the model explains 71.5% of the variance in the dependent variable. The model shows the positive relationship between the number of trips produced by the shop and the number of employees. That means if the number of employees is increased, they can deal with more customers, resulting in the sales of the shop increasing and trips also increasing. The model shows a negative relationship between the trip produce and the distance between the market and the transport office.

5.2.3 Model validation

The FTA and FTP models are validated by survey data. The data from 10 shops is randomly selected for the survey data, and the values of independent variables are placed in the model to validate the model. Trip estimates by models are approximately the same as the actual trips. So, these models can estimate the true number of trips coming and going from the shop. With the help of these models and the data of the shop, the trip generation and attraction from the shop can be estimated. This can be useful for urban planning and developing a framework for sustainable freight trips.

5.3 Traffic study at Gheekanta market

As discussed in the Traffic Volume Survey, the traffic survey was conducted at six different locations in the market from 8 a.m. to 9 p.m. From the survey, the number of vehicles (freight or passengers) that visited the market on any given day is calculated. Also, category-wise distribution of various vehicles is carried out. The volume of freight vehicles in the overall traffic is also calculated. Vehicles are multiplied by Passanger Car Unit (PCU) values to convert all types of vehicles into one unit. The PCU values of different types of vehicles are shown in Table 5. PCU values are as per IRC 106-1990 [2].

Table 5 Recommended PCU factors for various types of vehicles on urban roads

Sr No.	Vehicle type	Equivalent PCU Factors
1.	Two wheelers Motor	0.75
2.	Passenger car	1.0
3.	Auto-rickshaw	2.0
4.	Light commercial vehicle	2.0
5.	Truck or Bus	3.7
`6.	Cycle	0.5
7.	Cycle rickshaw	2.0
8.	Hand cart	3.0

As per (Indian Road Crogress) IRC 106-1990

5.3.1 Total trips from the Market

The total trips coming in and out of the market are shown in the Figure 5. Trips of freight vehicles such as 3-wheeler rickshaws and 3-wheeler pedal rickshaws and trips of passenger vehicles such as 4-wheelers, 2-wheelers, passenger rickshaws, and bicycles are considered as total trips. In the market the peak hours of the traffic are between 12:00 p.m. and 1:00 p.m. The Table 6 shows the total volume count of inflow and outflow from the market in PCU/day. Location 2 has the highest inflow and outflow it is because Gheekanta court is located near the location 2.

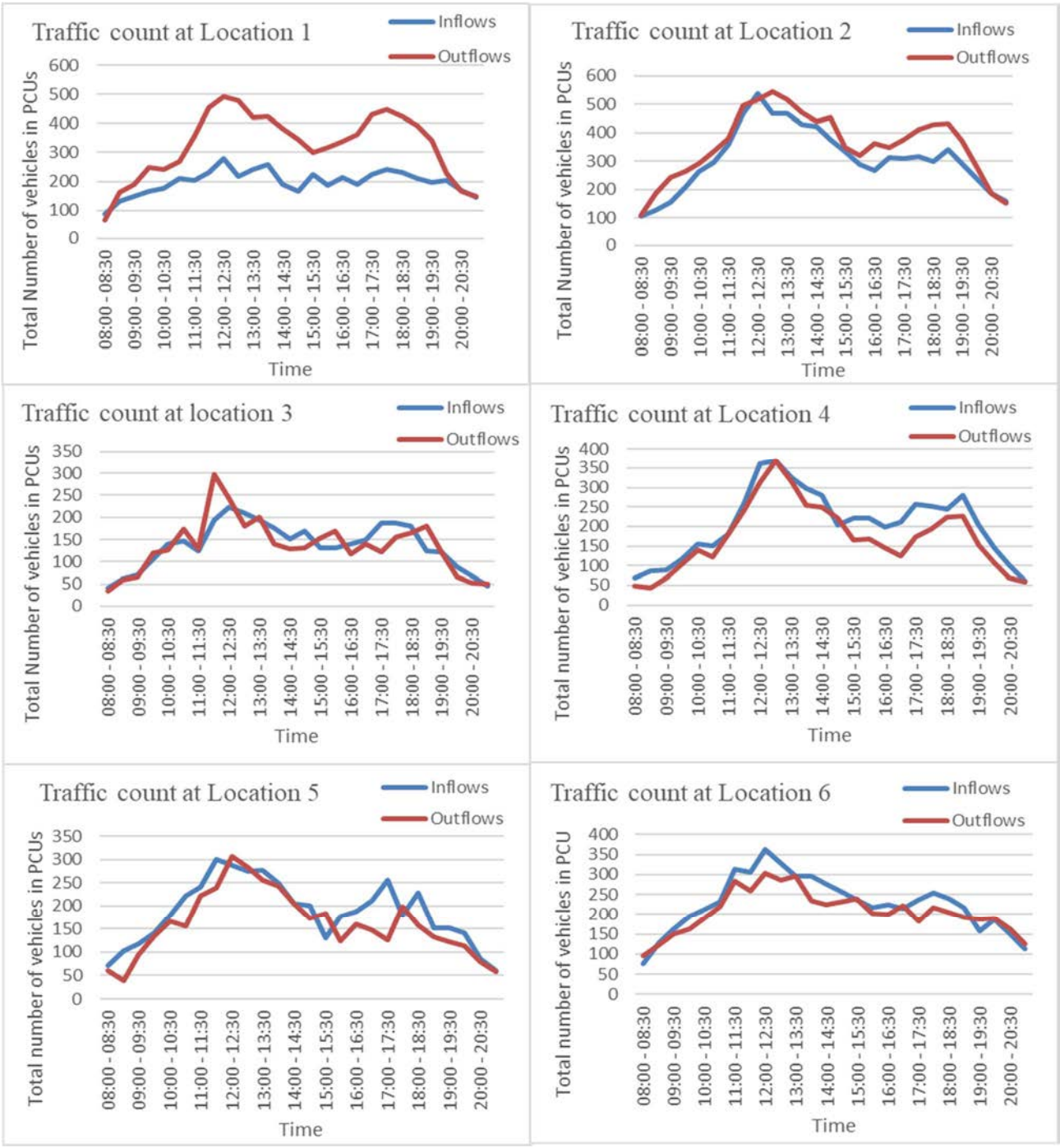


Figure 5 Traffic volume count of total trips at different six locations

Table 6 Total volume count in PCU/day

Location	Inflows (PCU/Day)	Outflows (PCU/Day)
1	5140	8417
2	8020	9266
3	3567	3524
4	5344	4482
5	3989	3523
6	4958	4826

5.3.2 Total Freight trips from market

The total freight trips produced and attracted by Gheekanta Market are shown in Table 7, in which only trips of freight vehicles are considered. The passenger 3-wheeler used for goods transport is also being considered. 2-wheelers are also used for goods movement in the market, but they are not included. The Figure 6 show freight trips from different locations throughout the day. Trips for freight vehicles begin around 9 a.m. And after 9 p.m., the trips go to zero.

The road that connects Location 4 and Location 1 is the central road that runs through the market, and most of the shops in the market are located on this road. Trips from other places are few compared to these two places. The market has a narrow road of about 7-8 meters. As a result, congestion occurs frequently on this road. This is the busiest street in the market.

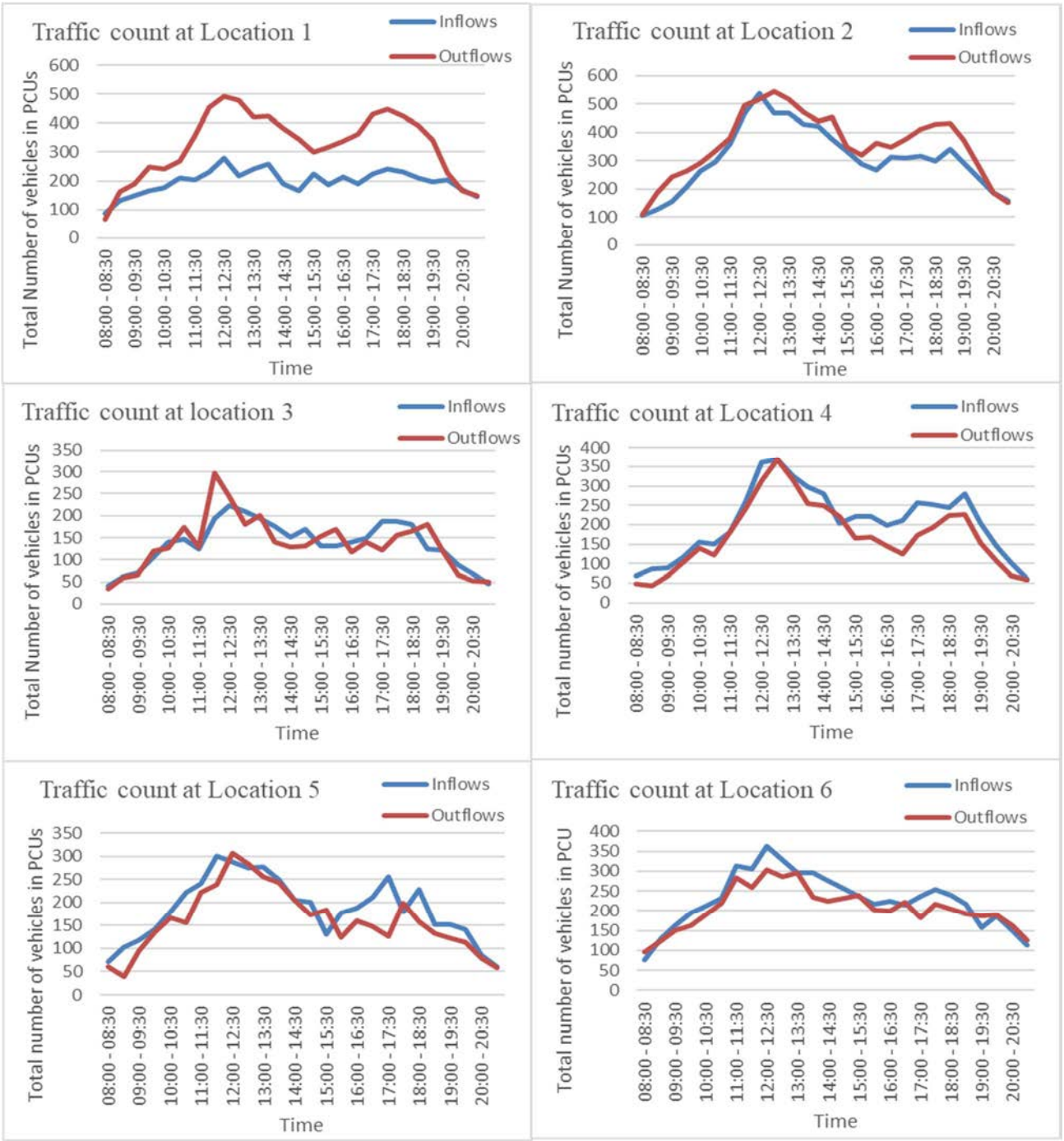


Figure 6 Total Freight trips at different six location

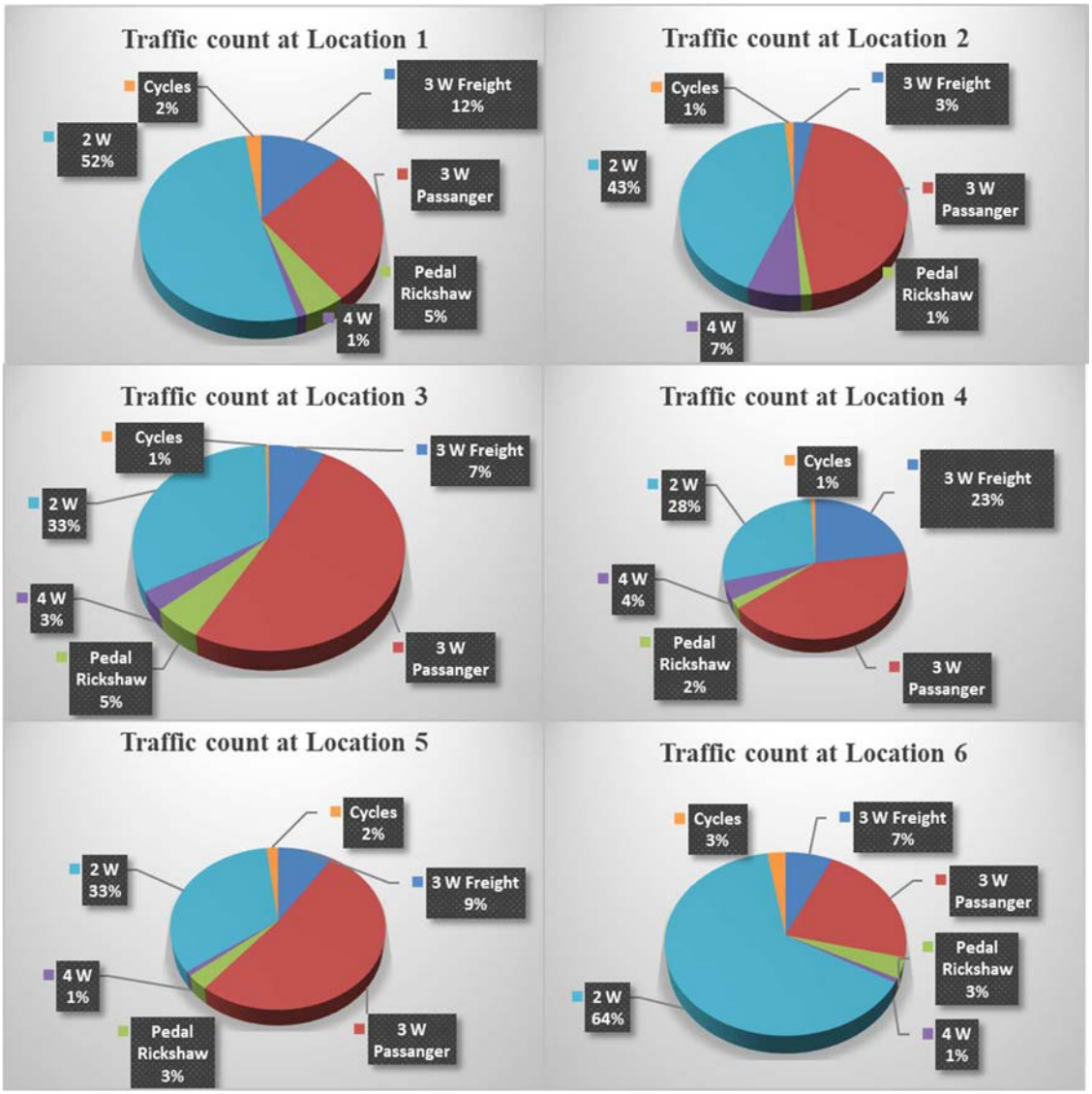
Table 7 Total fright trip incoming and outgoing from the market

Location	Inflows (PCU/Day)	Outflows (PCU/Day)
1	1034	1292
2	368	404
3	440	444
4	1330	1092
5	570	512
6	590	438

5.3.3 Category-wise distribution of traffic

Locations 1 and 4 show a higher percentage of freight vehicles than other locations, which is about 18% to 25%. In distribution (Figure 7), 2-wheelers have the highest percentage, averaging 43%. The 2nd highest percentage of passengers is 3-wheelers, which is 40% on average. The passenger 3-wheeler is mostly used by visitors. The use of 4-wheelers in the market is very low.

In category wise distribution, non-motorised vehicles, that is, pedal rickshaws, which are used for freight transport, have a very small percentage. But non-motorized vehicles like pedal rickshaws cause congestion in the market as their speed is slow, so they slow down other motor vehicles following them. Due to the narrow road, motorised vehicles cannot overtake pedal rickshaws. As a result, long queues are formed.



(Abbreviation : 2 W:- 2 wheeler, 3-W:- 3 wheeler, 4 W:- 4 wheeler)

Figure 7 Category-wise distribution of traffic

5.3.4 Loaded vs Empty Freight trips

In the market, if a freight vehicle comes to drop off goods, it may be emptied on return. In the same way if a freight vehicle takes goods from the market and goes to its destination, it will be empty in return. The follow graph shows how many freight vehicles enter and leave the market full and empty. In freight vehicle driver's survey, about 25% driver said that some time they return with the goods.

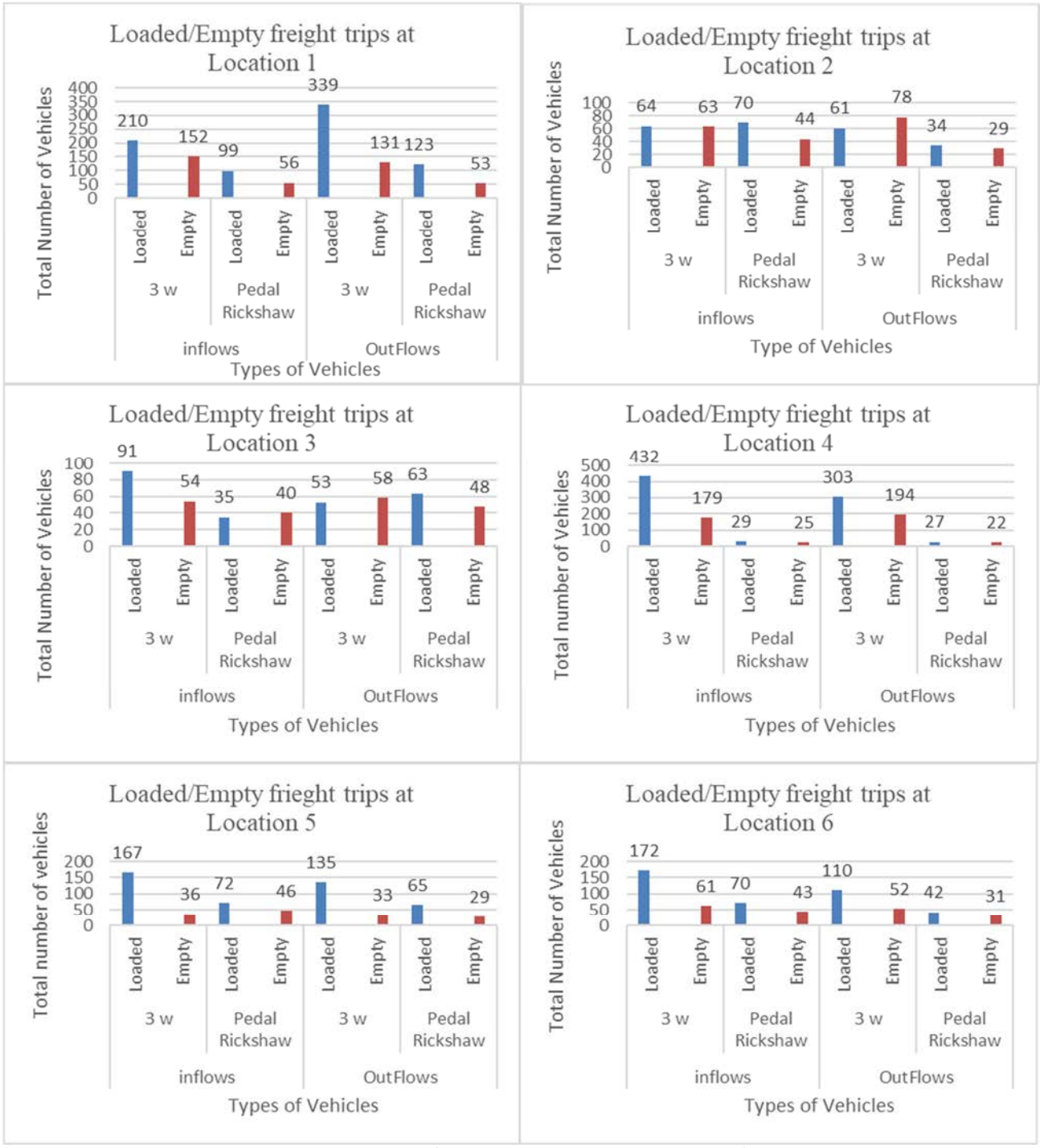


Figure 8 Loaded and empty freight vehicles incoming and outgoing from market

From the Figure 8, it is seen that almost an equal number of empty trips are generated and attracted from the market as compared to loaded trips. This means that all the freight vehicles either come to the market to deliver the goods, or they go from the market to another

destination to deliver the goods. They will be empty when they return from the trip.

5.4 Parking condition in the market

The survey determines the types of vehicles that market owners and employees bring to the market. Most employees come in private 2-Wheeler vehicles, which is about 60% of the total employees. Another 23% of employees come to the market by bus (public transport), another 10% of employees come by walking and another 7% of employees come by rickshaw (Figure 9). Employees who come with a private vehicle park 69% of their vehicles in the basement parking lot and the remaining 31% park their vehicles in on-street parking (Figure 10). This vehicle stays in the park all day. The short-term use of on-street parking by visitors is not considered.

All the vehicles used for the transportation of goods in the market are hired vehicles, and about 73% of the transport is by 3-wheeler rickshaw, 21% by 3-wheeler pedal bicycle, and 6% by 2-Wheeler Scotty (Figure 11). About 54% of those vehicles are parked on the premises during loading/unloading and the remaining 46% are parked on the street (Figure 12). Freight vehicles or other vehicles that use on-street parking They cover both sides of the road and reduce the width of the road. which causes traffic problems.

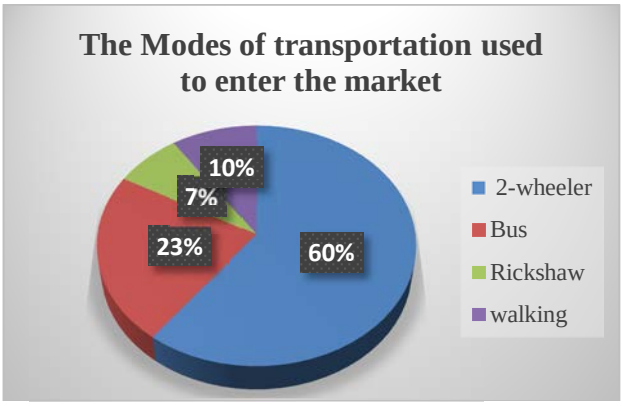


Figure 9 Vehicles used by employees to enter the Gheekanta market

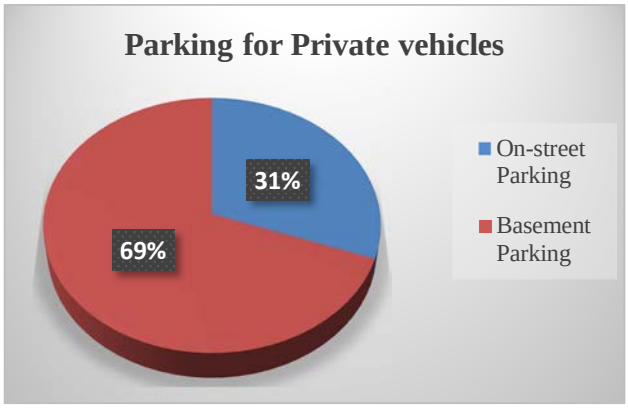


Figure 10 Parking of private vehicles in the market

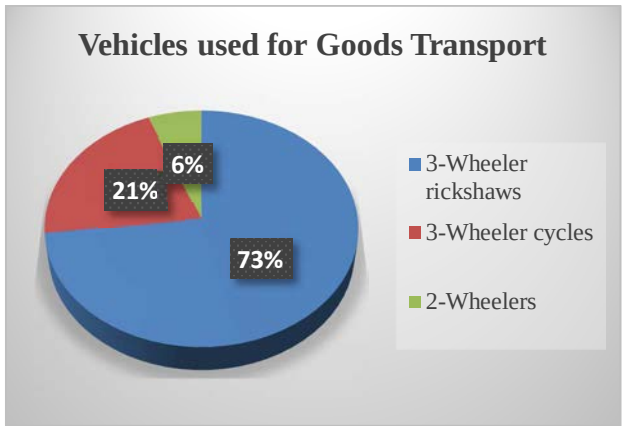


Figure 11 Vehicles used for goods transportation in market

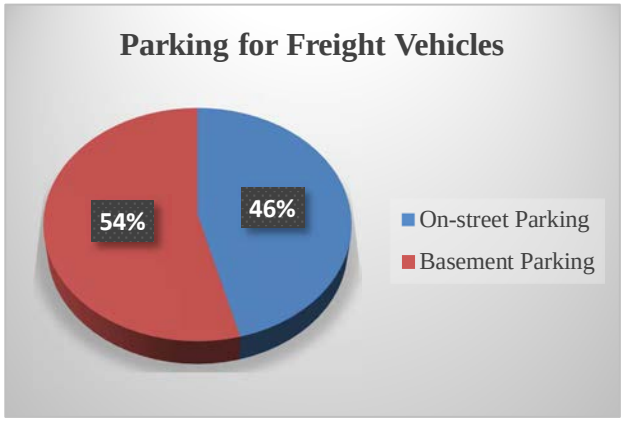


Figure 12 Parking facilities for goods vehicles in the market

6 Conclusion and way forward

For the economic development of any city, freight transportation is as important as passenger transportation. because it serves necessary commodities and helps in the production. But when freight transport comes into contact with urban areas, it creates negative impacts such as congestion on urban roads, extra noise and air pollution, etc. This study was carried out at Gheekanta wholesale market, Ahmedabad. Two models were developed in this study to estimate the number of trips produced and attracted by market. The freight trip attraction model has an R Square of 0.704. In this model, the number of trips attracted by shops depends on the quantity of incoming goods in the shop, the average floor area of the shop, and the distance between the transport offices to the Gheekanta market. The number of trips is increasing as the quantity of goods and the floor area of the shops increase. And trips decrease with increasing distance. The FTA model has significance F value and P-value in the statistical parameters are less than the critical value (0.05). That means a model can significantly predict the number of trips attracted by shops. The freight trip production model has an R Square of 0.715. The number of trips products by shops depends on the number of employees working in the shop and the distance between the market and the transport

office. The number of trips increases as the number of employees increases, and trips decrease as the distance increases. The FTP model has significance F value, and P-2values a'e less than the critical value (0.05). It means a model can significantly predict the number of trips produced by shops. In this market, the road that connects locations 1 and 4 is the main road of the market. on which a large number of vehicles are seen. Traffic congestion occurs frequently on this road. To reduce congestion, the main road of the market needs to be converted into a one-way street. It will reduce the congestion problem in the market and also increase the speed of vehicles, reducing travel time. The vehicles coming from other directions will travel from outside the market. The length of the main road is 1 km and the length of the road outside the market is 1.7 km, so the drivers will have to travel an extra 0.7 km. But it can give more benefits to the driver as there is extra fuel consumption and time delays due to congestion in the market. The market produces and attracts an equal number of loaded and empty freight vehicle trips, which causes extra load on the roads and congestion. For that, an online system needs to be developed in which drivers of freight vehicles are registered and goods are allotted to them by the system. This will reduce the number of unnecessary trips by empty freight vehicles. The market does not have parking available for about 31% of the private vehicles used by the shop owners and workers and 46% of freight vehicles. They parked their vehicles on the street, which encroaches on the road width and creates traffic problems. The market needs faster methods of loading and unloading, such as elevators, which transport goods faster than laborers in the complex. This has resulted in reduced parking time for freight vehicles during loading and unloading. The market attracts 31018 PCU/day trips in one day and produces 34038 PCU/day trips. which causes air pollution in the market. To reduce air pollution, eco-friendly freight vehicles like EV rickshaws should be used in the market. The study focuses mainly on the Gheekanta market in Ahmedabad. The study takes into account the trips between the market and the transport offices within Ahmedabad. The impact of freight traffic on market traffic is being considered. The impact on overall city traffic outside the market has not been taken into account. which can be considered as a future study. The model generated in the study can be used for planning of similar types of markets.

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DIVIDEND POLICY AS A SUPPLY OF COMPANY FINANCIAL FLOWS IN THE PERSPECTIVE OF INFORMATION ASYMMETRY AND OWNERSHIP STRUCTURE
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DIVIDEND POLICY AS A SUPPLY OF COMPANY FINANCIAL FLOWS IN THE PERSPECTIVE OF INFORMATION ASYMMETRY AND OWNERSHIP STRUCTURE

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Keywords: dividend policy, controller shareholder, information asymmetry, agency conflict, institutional ownership.
Abstract: Dividend policy is one of the important factors that supply the company's financial flows and operational activities. This study examines the determinants of dividend policy from the perspective of information asymmetry and institutional ownership. The research sample is the companies listed on Indonesia Stock Exchange that pay dividend consecutively from 2016 to 2020. The method of analysis is SEM-PLS operated with WarpPLS 8.0. The results showed that high information asymmetry between company management and shareholders encourages managers to reduce dividend payments for the purpose of providing company capital and production activities. Furthermore, the existence of institutional ownership supports managers' policies and prefers that company profits should be used to supply capital, not be distributed to shareholders. This finding is consistent with the pecking order theory and also implicates the need for a corporate governance system to be improved to give better protection to the investors.

1 Introduction

Dividend policy is one important decision made by the company. Empirical studies had been carried out to investigate determinant factors that influence dividend policy [1-5]. There are several theories used to explain the behavior of dividend policy. For instance, *pecking order* theory was used by Myers and Majlub [6] to explain that the company shall give priority on internal sources of funding, including retained earnings. This priority convinces the company to choose low dividend policy and to allocate the other proportion for reinvestment. Under *pecking order* theory, low dividend payout is associated with high information asymmetry. The managers hold the cash to finance investment projects and to avoid from generating funds with high capital cost, such as the fund from creditor loan with high interest rate or the fund from the offering of new share at low price [6,7].

Meanwhile, in *trade off* theory, the company is required to take priority on external funding (including loan) to finance the corporate projects at predetermined limitations [6]. However, this priority implicates to high dividend payout. The relationship between high dividend payout and high information asymmetry is compatible with *signaling* theory which says that dividend policy is a signal sent by the company to the market in order to reduce information asymmetry [8]. In this context, *signaling* theory is inherently corresponding to *trade off* theory but not in line with *pecking order* theory. This theoretical gap engenders several empirical studies on the relationship between information asymmetry and dividend policy [9-14]. Three of those studies, respectively Okpara [14], Sahar and Mayahi [11], and Harakeh, et al. [12], are supporting the use of high dividend policy as a signal to reduce information asymmetry. This position is in accord with both *signal* and *trade off* theories. Meanwhile, other empirical studies are more conforming to *pecking order* theory which advocates the negative relationship between information asymmetry and dividend policy [9,10,13].

Another studies were examining the contribution of ownership structure to the effect of information asymmetry on dividend policy. For instance, Lin, et al. [15] found that Chinese companies managed under state ownership control tend to pay dividend higher than the companies that are not controlled by the state. The allocation of shareholding has been reformed which has implicated to the improvement of information transparency and the strengthening of positive effect of information asymmetry on dividend policy. In addition, Lepetit, et al. [16] discovered that European banking companies with concentrated ownership and high information asymmetry are inclined to pay low dividend.

This finding was consistent to *entrenchment* behavior hypothesis which says that the *insiders* (manager or majority shareholder) are prone to pay low dividend to collect lucrative personal gains in the situation of high information asymmetry. The results of the studies above explain that dividend payout can alleviate agency conflict by decreasing information asymmetry. However, the effectiveness of dividend payout is still determined by the controller of corporate ownership. If the controller shareholding is through state ownership, then dividend payout can minimize agency conflict. Conversely, if the ownership is concentrated on majority shareholders, whom are mostly non-state owners, then these shareholders tend to ignore the consequence of high information asymmetry and give more focuses on personal interest.

In the context of Indonesia, the impact of information asymmetry on dividend policy through ownership structure was not yet deeply studied. The latest relevant study was carried out by Setiawan, et al. [17] which the finding was in agreement with Lin, et al. [15]. The finding showed that the company with state ownership has moderated positively the effect of information asymmetry on dividend policy in Indonesia. Most of Indonesian studies only associate the effect of ownership structure on dividend policy and never discuss information asymmetry [5,18-20]. The current research follows up the Indonesian studies by conducting review on the role of ownership structure in responding information asymmetry and in affecting dividend policy. The contribution of this research is on the review of the effect of information asymmetry on dividend policy by using ownership structure as moderation variable. In the context of this research, ownership structure is represented by institutional ownership. The objective of this research is therefore to find out the role of institutional ownership structure in handling information asymmetry and dividend policy.

The result of the current research indicated that information asymmetry has negative effect on dividend policy and also that institutional ownership negatively moderates the effect of information asymmetry on dividend policy. This research is outlined into several sections. First section is for introduction. Literature review and hypothesis development are put in the second section. Subsequently, third section is for method of research. The fourth section is allotted for result and discussion. Finally, the conclusion is placed on the fifth section.

1.1 Information asymmetry and dividend policy

Information asymmetry takes source from a situation when fundamental information concerning the company are not evenly distributed to the investors [21,22]. The lesser fundamental information owned by the investors will impact on the higher risk taken by investors in making investment decision. In this matter, dividend policy can minimize high information asymmetry. Agency theory may reduce information asymmetry between the company and the investor. The managers can do corporate action by stipulating high dividend policy [23]. Under the context of dividend policy, agency theory is in conformity with *trade off* theory [6] and getting a support from *signaling* theory [8]. Anyway, theories that support the role of high dividend policy in decreasing information asymmetry are advocated by further empirical studies done by Okpara [14], Sahar and Mayahi [11], and Harakeh, et al. [12]. The opposite findings declared that high information asymmetry is not followed by high dividend payout [9,10,13]. Low dividend policy signifies that the managers give high priority on personal interest and consider the majority owners as the controller of the company. Related to this statement, the first hypothesis is written as follows:

H1: Information asymmetry affects dividend policy.

1.2 Institutional ownership, information asymmetry, and dividend policy

The companies in the developing countries where the corporate governance system is poor and the protection for shareholders is weak tend to pay lower dividend [24]. In contrast, the companies in the developing countries with good corporate governance system always pay higher dividend [25]. Ownership structure enables the company not only to supervise the managers but also to attain the corporate goals. Therefore, ownership structure affects capital structure composition, profitability and dividend payout [26]. The effect of ownership structure on dividend policy may differ depending on the type of ownership structure and also on whether the corporate governance system is good or bad. The study carried out by Lepetit, et al. [16] documented that the concentrated ownership in European banking companies have impacted low dividend payout during the situation of high information asymmetry. This study also reported that the concentrated ownership has moderated the effect of information asymmetry on low dividend policy. Else, the study conducted by Jory, et al. [27] demonstrated that institutional shareholders with major and stable ownership percentage are preferring the company to pay dividend. Other study was performed by Reyna [28] which the finding indicating that institutional ownership can minimize agency problem through managerial control by maximizing dividend payment. Moreover, Setiawan, et al. [17] confirmed that state ownership leads to higher information asymmetry which must be minimized by high dividend policy. A question emerges, which is, “How is about the private companies that are dominantly held by institutional ownership?” According to the current data, Indonesian institutional ownership is dominated more by the ownership from “corporate” institutions rather than financial organizations (insurance, retirement fund, mutual fund, security and other financial institutions). The dominant shareholders in “corporate” institutions become the majority shareholders, or also called the controller shareholders. Concerning with this matter, the controller shareholders have strong control on the company which implicates to the expropriation over non-controller shareholders. A public opinion says that the

controller shareholders have strong proclivity to scale up their personal gains whereas the non-controller shareholders do not do such thing [29]. Basically, the institutional ownership in Indonesia companies is not willingly minimizing information asymmetry by paying higher dividend, as justified by Jory, et al. [27] and Reyna [28]. Based on the statement above, the second hypothesis is formulated as follows:

H2: Institutional ownership generates high information asymmetry through low dividend policy.

2 Methodology

2.1 Data of research sample

The research sample is acquired through non-probability sampling with criteria. This sampling method is also called purposive sampling. The criteria include that (1) the companies were listed on Indonesia Stock Exchange from 2016 to 2020; (2) the companies were distributing dividend periodically and consecutively during the research period; and (3) the companies have an institutional ownership structure. After applying the criteria to the sample, there were 63 companies considered eligible and there were 315 observation data obtained (63 x 5 years).

2.2 Research variable and measurement

Dependent variable is dividend policy measured by dividend ratio. Referring to Elmagrhi, et al. [30], the dividend ratio is defined as the comparison between the cash dividend paid and the total assets owned by the company every year during the research period. the Dividend ratio can be calculated by dividing the total cash dividend by total assets.

The Independent variable of this research is information asymmetry, which is rendered as a situation when the fundamental information about the company is not evenly distributed to the investors [21]. According to Sahar and Mayahi [11], the current research measures information asymmetry by using the information of the lowest bid price and the highest ask price in period t (the research period). Information asymmetry is calculated by subtracting the highest ask price from the lowest bid price and then dividing by the addition of the highest ask price the lowest bid price divided by two.

Meanwhile, the moderation variable is institutional ownership which is measured by the percentage of share owned by institutional investors [27,28]. The authors of the current research are wishing to control all variables and therefore, two control variables, namely size and leverage, are used. Size is measured as the result of natural logarithm on total assets whereas leverage is the result of comparison of total liability with total assets [11,19].

2.3 Analysis model

Method of analysis is Partial Least Squares (PLS) - Structural Equation Modelling (SEM) which is operated using a program named WarpPLS version 8.0. A hypothesis test is conducted also with this program. Equation model describing research hypothesis is formulated as follows:

$$D = a + b_1IA + b_2 + b_3S + b_4L + b_5IO*D + e \quad (1)$$

where:

D = dividend ratio, IA = information asymmetry, S = corporate size, L = leverage, and IO = institutional ownership.

3 Result and discussion

3.1 Descriptive statistic

The results of descriptive statistic test, which include maximum value, minimum value, mean value, and standard deviation value, are presented in Table 1.

Variable	Min	Max	Mean	SD
Information Asymmetry	0.053	1.653	0.550	0.297
Institutional Ownership	0.045	0.997	0.673	0.186
Dividend Ratio	0.0001	0.4452	0.050	0,081
Size	18.195	33.495	27.641	3.610
Leverage	0.071	0.820	0.397	0.184

Table 1 Descriptive statistic test
Source: Secondary data of Indonesia Stock Exchange are processed

Following the contents of Table 1, information asymmetry has mean value of 0.550. This result signifies that there is a gap between perceived corporate performance (as perceived by investors) and actual corporate performance. The gap is in the range of 55.5%. The minimum value and the maximum value of information asymmetry are 0.053 and 1.653. The standard deviation value of this variable is 0.297. The value of standard deviation is smaller than mean value (0.297<0.550), which indicates that data are not varying and not distributed.

Institutional ownership has a mean value of 0.673, which explains that all companies in the research sample are owned in the majority by institutional ownership, precisely over 50% or 67.3% on average. The minimum value and the maximum value of institutional ownership are 0.045 or 4.5% and 0.997 or 99.7%. The deviation standard value of this variable is lower than mean value (0.186<0.673), which denotes that data are less varying but closer to the mean value.

The dividend ratio has a mean value of 0.050. This result affirms that on average, the company distributes cash dividends for 5% of asset value. The minimum value and the maximum value of dividend ratio are 0.0001 and 0.445. The deviation standard value of this variable is higher than mean value (0.081>0.050), which informs that data are varying and distributed.

Furthermore, size has mean value of 27.641 (in logarithm) or 13.899 trillion (in Indonesia rupiah). Of 315

observations, the size of the companies in this research is in the large category. According to constitution No.20, 2008, a large company is a company with an asset value of over 15 billion rupiahs. The leverage value of the research companies is 0.397 or on average, the proportion of 39.7% of the corporate funds is derived from the debt.

3.2 Goodness of Fit test

Goodness of Fit test is aimed to find a model that is fit the original data. The evaluation of whether the model is fit or not is needed to measure the model quality. The results of Goodness of Fit test are shown in Table 2.

Table 2 Goodness of Fit of structural model

Criteria	Parameter	Rule of Thumb	Conclusion
Average path coefficient (APC)	0.119, P=0.004	Acceptable P < 0.05	Accepted
Average R-squared (ARS)	= 0.269, P=0.038	Acceptable P < 0.05	Accepted
Average adjusted R-squared (AARS)	= 0.257, P=0.060	Acceptable P < 0.1	Accepted
Average block VIF (AVIF)	1.110	acceptable if ≤ 5, ideally ≤ 3.3	Accepted
Average full collinearity VIF (AFVIF)	1.053	acceptable if ≤ 5, ideally ≤ 3.3	Accepted
Tenenhaus GoF (GoF)	0.263	small ≥ 0.1, medium ≥ 0.25, large ≥ 0.36	Accepted

Source: Secondary data of Indonesia Stock Exchange are processed

In accordance with the contents of Table 2, the research model has met the parameters of goodness of fit. For instance, all p-values for APC, ARS and AAR are similarly < 0.1, which respectively are APC = 0.119, ARS = 0.269 and AARS = 0.257. The values of AVIF and AFVIF are 1.110 and 1.053, which fulfill the criterion that requires the value to be ≤ 3.30. This position indicates that there is no multicollinearity problem across exogenous variables. The value of Tenenhaus GoF is 0.263 (≥ 0.25), which signifies that the predictive power of the model is in the medium category and considered to be acceptable. As a whole, the results of Goodness of Fit test declare that the research model has a very good fit. This position clarifies that the evaluation model is fit with the data.

3.3 Estimated relationship across variables

The analysis of the significant relationship across variables (involving main variables and control variables) is conducted to answer research questions or hypotheses. The results of estimated relationship across variables are displayed in Table 3.

Table 3 Effect Across Variables

Description Path	Path Coefficient	R^2	Q^2
Information Asymmetry to Dividend Ratio	-0.079**	0269	0.276
Institutional Ownership * Information Asymmetry to Dividend Ratio	-0.071*		
Size to Dividend Ratio	0.168***		
Leverage to Dividend Ratio	-0.159***		

***, **, * denote significance levels at 0.001, 0.05 and 0.1, respectively
Source: Secondary data from Indonesia Stock Exchange are processed

According to the contents in Table 3, the value of Adjusted R-Square (R^2) is 0.269, which affirms the variation of information asymmetry, the interaction between institutional ownership and information asymmetry, and the presence of control variables can affect dividend policy by 26.9%. Meanwhile, the remaining 73.1% is affected by other factors beyond the research model. The value of Q-Square (Q^2) is 0.276(>0) which indicates that the research model has predictive validity. The first hypothesis says that "information asymmetry affects dividend policy". The output in Table 4 shows that information asymmetry has a negative and significant effect on the dividend ratio. The path coefficient value of this relationship is -0.079. This result supports the hypothesis, which therefore Hypothesis 1 is accepted. Meanwhile, the second hypothesis states that "institutional ownership generates high information asymmetry through low dividend policy". The output in Table 4 exhibits that the interaction of institutional ownership and information asymmetry has a negative and significant effect on dividend ratio. This position is justified by a path coefficient value of -0.071. In other words, institutional ownership moderates negatively the effect of information asymmetry on dividend policy. This result supports the hypothesis, which therefore Hypothesis 2 is accepted.

The relationship between control variable and dependent variable has a positive and significant effect on the dividend ratio. The larger size of the company is associated with a higher dividend payout policy. In addition, leverage has a negative and significant effect on the dividend ratio, which denotes that when the company has a higher debt level, then dividend payout policy becomes smaller.

3.4 Discussion

3.4.1 Effect of information asymmetry on dividend policy

First hypothesis stating that "information asymmetry affects dividend policy" was put on the test. The result of the test showed that path coefficient value of the relationship is negative but significant (p-value<0.05). This result supports the hypothesis which signifies that information asymmetry affects dividend policy negatively. Or, high information asymmetry is associated with dividend payout policy. This finding is not in line with agency theory that requires the managers to do corporate action, including high dividend payout policy, in order to alleviate information asymmetry between company and investor [23]. On the other hand, this finding is consistent to the statements given by Deshmukh [9], Li and Zhao [10], and Kim, et al. [13], which indicated that high information asymmetry is not followed by high dividend payout policy. In the sample companies, dividend were paid. Descriptive statistic data indicated that in average, the companies pay dividend ratio for 5% of total asset. Meanwhile, the data of information asymmetry experienced by investors regarding fundamental information about the company are reaching 0.55 or 55%. Two arguments are given to this position. The first argument says that dividend policy is not used by corporate management as an instrument to minimize information gap but used more to create better corporate image. More specifically, dividend policy is like "entrenchment" but oriented toward personal favor of the manager. The second argument asserts that high information asymmetry is associated with irrational behavior of the investors. The decision of investors is not underlain by fundamental information factors but more dominated by psychological factors. This situation is in agreement with the finding given by Sumani, et al. [31] which stated that the behavior of Indonesian individual investors is generally irrational in their investment in capital market. The corporate value does not reflect the intrinsic value of the company. Therefore, the effect of corporate fundamental value on corporate market value is not consistent at all.

3.4.2 Role of institutional ownership in moderating the effect of information asymmetry on dividend policy

Hypothesis test was also applied on second hypothesis which states that "institutional ownership generates high information asymmetry through low dividend policy". The result of the test indicated that the role of moderation of institutional ownership in the effect of information asymmetry on dividend policy has a path coefficient value which is negative and significant (p-value<0.1). By this result, the hypothesis is supported and therefore accepted. Besides, this result clarifies that institutional ownership extenuates information asymmetry to improve dividend payout. This research corresponds to *pecking order* theory explained by Myers and Majlub [6]. This theoretical version urges the company to emphasize on internal funding such as retained earnings, which thus requires the company to set low dividend payout policy and to allocate the major proportion for reinvestment. This result is in conflict with agency theory that suggests high dividend payout to alleviate agency conflict. In other words, institutional ownership is preferring low dividend payout despite high information asymmetry. In line with Porta, et al. [24], the corporate behavior in developing country with poor governance system tend to pay low dividend and to be powerless in protecting the minority investors. Indonesian institutional investors are dominated by corporate institutions. As majority and also controller shareholders, institutional investors use their power to benefit themself from various important decisions, including the decision about dividend payout.

Institutional shareholders as the corporate controller often increase their wealth by not paying dividend or by paying low dividend. In this situation, institutional shareholders use dividend policy to acquire personal gains from their control. The incentive toward such personal gains is increasing because the controller shareholders will only lose dividend payout that is proportional to their right of cash flow. Despite this lose, the controller still can get full personal gains from the expropriation. Moreover, institutional shareholders as the corporate controller show a stronger preference to get personal gains rather than non-controller shareholders such as individual or minority shareholders [29]. This argument explains the role of institutional ownership structure in Indonesia in responding high information asymmetry through low dividend policy. This role is different from state ownership which tends to increase dividend policy in encountering high information asymmetry [17].

4 Conclusion

This study examines how the behavior of management and company owners in distributing dividends in Indonesia. Dividend policy greatly influences the distribution of cash on operational activities. The results show that in the context of high information asymmetry, company management tends to pay dividends with low ratios. Although the company continues to distribute dividends, the dividend policy implemented by the company's management is not used as an instrument to reduce information asymmetry, but is used to create a good corporate image or is a " entrachment ". Furthermore, high information asymmetry and low dividend policy are followed by market behavior (public investors) that is not rational in which their investment decision is dominated by psychological factors rather than by corporate fundamental information.

Another major result shows that the controlling shareholder, in this case, institutional investors, actually supports a low dividend policy. The dominant institutional ownership of corporate institutions uses their power to take advantage by encouraging low dividend payments but

getting full private benefits for their expropriation actions. As the majority and controlling shareholder, institutional investors exercise their power in their favor in various important decisions, including decisions about dividend payments.

Theoretically, the current research supports the pecking order theory that gives priority on internal funding such as retained earnings. The sample companies tend to set a low dividend policy. The practical implication of this research is that a weak governance system causes low protection for individual investors, therefore the government can improve governance regulations and disclosure of information that can better protect minority investors.

Research limitation

The current research only uses secondary datas and has not explored yet the primary datas. A direct interview is conducted by the authors with the corporate manager to get information or data about dividend policy and information asymmetry. The collected data are expected to be complete and comprehensive. Further research shall use the mixed method in data collection.

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ECOLOGICAL SOLUTION OF GOODS PACKAGING FOR B2C LOGISTICS

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Keywords: packaging efficiency, ecological packaging, supply chain management, solution selection.
Abstract: The publication describes the development of a new method suitable for selecting an environmentally friendly packaging solution in B2C logistics, which is currently facing major challenges. The key for developing the new method is the fact that the selection process is greatly influenced by the ecological aspects of the supplier's solution and the efficiency of working with the proposed solution, as these are the key aspects of the future in logistics. In the results and discussion, we will focus on a specific company that currently uses 14-size variants of cardboard packaging. Based on our analysis, we reduced these to four variants and streamlined the process of ordering, handling and storage of cardboards. Using the OEE metrics, we calculated the feasibility of this solution, which was only at the level of 65% compared to the metrics set by the company's management. With the help of the suppliers, we have designed a new solution that was tested under the same conditions using the OEE metrics. In the test, we have reached the level of 98%, which means a 33% increase in efficiency. At the same time, this solution is highly environmentally friendly and does not use polypropylene adhesive tapes, which pollute the environment. We then compared the results and evaluated the best quotes for both types of cardboards. The newly designed solution is only 4.9% more expensive than the currently used type of cardboard. Based on the results achieved, we can conclude that the new method offers companies the most advanced approach to choosing a suitable solution for B2C logistics.

1 Introduction

The rapidly growing B2C business is putting small and medium-sized enterprises in the position of having to manage this growth despite the labour shortage in the market. Companies are appearing on the market that cannot cope with their rapid growth and therefore cannot keep up with orders from their customers. This situation gives rise to quick and ill-advised management decisions that are driving these companies into gradual liquidation. Rapid growth is, therefore, a precursor to rapid decline. In order to be able to manage these processes, thorough analyses and systematic and well-thought-out plans based on previous analyses are needed, followed by flexible decisions responding to the rapidly changing situation, which are also based on thorough analyses.

Logistics represents an important factor of success, and unfortunately, logistics personnel is generally less available on the market than other personnel. Managers must therefore pay close attention to the efficiency of their personnel to be able to invest funds in their quality. The survey, commissioned by the renowned portal profesia.sk indicate a more than 25% increase in wages over the last three years in logistics, compared to an 8% average wage increase in the market. This is caused by a huge lack of employees suitable for this position. We therefore recognise that the pressure on logistics efficiency is significant and inevitable in the future. In B2C companies, logistics staff make up 20-40% of all labour costs.

On the other hand, there is an excess of online retailers and the need to differentiate from the competition. The younger generation is placing more emphasis on the ecological side of the business and is therefore looking for retailers and products that promote environmental sustainability. While in the past, the ecological factor made up only a negligible part of consumer decision-making, it is currently at over 15%, with an estimate that by 2030 it will influence up to 50% of consumer decisions. (source: public market research on a sample of 1000 respondents created by the company in which the study was applied).

Authors describing the selection of packaging material suppliers do not sufficiently emphasise the aforementioned rapidly evolving aspects, which motivated me to research and develop a new method. The development of the method continued with a systematic literature review of existing supplier selection methods. This is covered in the second part of the publication. The third section contains a detailed description of the proposed method of supplier selection itself. The fourth part presents a specific case of the newly created method and its contribution to society in the field of ecology and increasing the efficiency of processes. The selection of a suitable supplier and solution is then compared with the previous state. I believe that, based on practical experience, the developed method can be successfully implemented in various businesses working in the field of B2C trade.

2 Literature review

The literature review was carried out based on the use of keywords. In their publications, the authors deal with the general definition of the supply chain and supply. Majtan defines supply as an efficient satisfaction of needs resulting from the planned course of basic, auxiliary and service

production and non-production processes, by securing deliveries [1]. Majduchova and Neumannova define it as the provision of raw materials, basic and auxiliary materials, purchased products and components, semi-finished products, spare parts, tools, preparations, overhead materials and aids for management and administration, social services and security of a company [2]. The definitions further state the basic parameters for selecting suitable suppliers while indicating the importance of the basic deciding factor. Synek defines the decisive factors to consider when selecting a suitable supplier such as flexibility, reliability, precision, quality, ability to deliver the required quantity, scope of service provided, location of the supplier, price, discounts, mark-ups, attitude towards the buyer, quality of packaging, etc. [3].

Despite all the traditional definitions, there are authors who specify in more detail the process of selecting a suitable supplier and begin to take modern decision-making factors into account. Elodie describes in its publication that the new generation of young people is not making decisions based on standard decision-making factors but emphasises new modern factors such as the supplier's approach to ecology, the ability to find a suitable solution for the customer and flexibility in decision-making [4]. Even here, we can only see a general view of the supplier in terms of ecology and flexibility, while the author does not address the issue of the specific decision-making factor with regard to the given solution for the customer. The authors base their opinions on many different approaches to supplier selection, such as deterministic and stochastic optimisation, Markov chain, simulations, Bayesian networks and so on [5]. Based on these approaches, we take a closer look at the literature related to lean, resilient, agile, green and sustainable paradigms in supplier selection. Individual approaches significantly influence the strategy of selecting suppliers and their subsequent evaluation. Therefore, we can divide this section into the lean supply chain, agile supply chain, resilient supply chain, green supply chain and sustainable supply chain [6].

2.1 Lean supply chain

The concept of the lean supply chain is defined as a philosophy of long-term growth for the customer, company or economy [7], leading to a value stream by eliminating waste, ensuring compliance with the plan by reducing cycle time, and eliminating waste by increasing quality and reducing cost [8]. Many companies are using lean principles to improve the efficiency of their supply chain processes. Successful implementation of lean management philosophy largely depends on the quality of suppliers [9]. The key outcome of a lean supply chain strategy is low-cost and high-quality products [10]. Therefore, the selection of metrics for lean suppliers often focuses on quality, cost, cycle time and delivery [11]. Some of the supply criteria include, but are not limited to, delivery date, delay, efficiency, and delivery time and status, among others. In our case study, we consider two criteria such as delivery time and safety and provision. Quality is also a critical concern for most businesses. Also, the need for quality suppliers has always represented an important issue. The quality assessment factors include quality systems, process quality, overall quality management, and certified product rate [12].

2.2 Agile supply chain

The concept of agile supply chain refers to the ability of suppliers to respond effectively to unpredictable customer needs. Agility can be defined as the ability to react rapidly and effectively to unexpected changes and to implement the necessary measures to successfully modify the design, production, marketing, and organisation of the company [13]. Agility in the supply chain is defined as a quick and effective response to changes in the market and customer demand [14]. In the current competitive business environment, to stabilise and improve their market position, organisations should be more agile and responsive to change. The agility strategy focuses on creating the ability to respond rapidly and effectively to unexpected changes in the market and the environment [15]. Suppliers play a key role in achieving agility towards the customer. Therefore, choosing the most suitable and agile suppliers represents a vital part of an efficient and productive company [16]. In general, the key attributes of agile suppliers include speed, flexibility and quality. One of the most important dimensions of agility is time. The ability to provide quality products and services as per customer needs and requirements play a vital role in agility and speed of growth and development. Regarding this aspect, we consider three criteria: consistent conformance to specifications, stability of quality, and the ability to provide a quality product/service [17].

2.3 Resilient supply chain

Resilience is a multidisciplinary concept and an exciting subject of scientific research in various disciplines such as psychology, ecology, economics, crisis management, sustainable development and supply chain risk management [18]. Resilience is the ability to bounce back from disruptive events or difficulties and return to the original situation after experiencing an anomaly or failure in a production system [19]. When talking about the supply chain, resilience also indicates the ability of the supply chain to cope with uncertainty while maintaining operational continuity [20]. Correct selection and evaluation of suppliers plays a key role in ensuring quality products and fair prices. One of the essential characteristics of a resilient supplier is the flexibility to source and deliver products efficiently. Companies using adaptive capabilities can effectively use knowledge to deliver products faster and cheaper than their competitors [21]. In addition, maintaining an excess of stock can stabilise the business in the event of a shortage of goods. Although maintaining

safety and additional stock is expensive, it helps to stabilise the relationship with the customer [22].

2.4 Green supply chain

Evaluation and selection of suppliers from an ecological perspective has become a widespread phenomenon in supply chain management [23] and has gained considerable interest due to the recent increase in environmental awareness [24]. With the development of local regulations and policies designed to reduce pollution and improve environmental sustainability, the management of green suppliers has become a critical factor in today's competitive market [25]. Traditionally, problems with supplier selection and order allocation have focused mainly on the product price, delivery time and quality without considering environmental impacts and issues [26]. Green-focused suppliers try to reduce pollution and minimise waste and environmental contamination, taking supply chain selection to a new dimension.

3 Methodology

The result of the study is the selection of a suitable supplier of packaging material for B2C logistics, focusing not only on the above-mentioned and commonly described criteria (price, quality, speed of delivery, etc.), but also on the efficiency of working with the product, the impact of the solution on the environment and the total cost of the entire packaging process. By using other methods, we gain a new perspective on the criteria for choosing a suitable solution and supplier. In this way, the company will receive more financial resources that it can invest in the development of the company and a competitive advantage that will help it gain a foothold in the market.

In our research, we use the OEE method (Figure 1), which is a quantitative indicator measuring the effectiveness of the packaging of goods, representing the percentage of the time required to package goods that were actually used productively. The indicator consists of 3 partial parts, which by their product, express the final value of the indicator. Achieving OEE=100% means that we have achieved 100% Quality in a given time, we have achieved 100% Performance (as fast as we could, or we met the objectively defined speed of packing time for a specific product) and we have achieved 100% Availability (we have had no downtime related to the availability of consumables). In this case, quality can be defined as the number of customer complaints that the company registers.

Figure 1 The formula for calculating the OEE method

To calculate availability and performance, we used the DEA method, which provides us with measuring the efficiency of warehouse staff when packing goods, while the method shows us the overall performance rate for each unit for given inputs and outputs. Its calculation consists of measuring the time of the given process. Using DEA, we can measure the time interval of each solution and obtain the input OEE method.

To calculate the total cost of the proposed solution, we will use the cost method, which takes into account all costs associated with purchasing, storage, handling and final processing.

The design of the comparative model consists in assigning a certain number of points to the assessed indicators, with the final score depending on the resulting value achieved. The resulting value is obtained using trivial formulas. The basis for the successful application of this method is the assignment of a primary number of points to each criterion and the setting of thresholds for the evaluation of the final values. Criteria that are not numerically expressed are assigned the number of values in descending order, meaning that the criterion that is most important is scored the highest.

4 Result and discussion

The basis for achieving the objective in the selected company was to design a reasonable number of size variants based on a physical analysis and measurements. Currently, the company uses 14 size variants (Table 1), which has a negative impact on the stock of packaging material and the efficiency of the warehouse staff. Based on a 10-day measurement, we proposed 4 size variants that can cover the company's need with efficient use of filling material.

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Tabel 1 Summarisation of currently used cartons and design of new variants

Size variant (LxWxD) cm	Consumption (10 days)	% share of the total amount	Superseded variant (LxWxD) cm
280x200x150	135	6,1%	300x200x150
200x200x150	76	3,4%	
310x180x150	12	0,5%	
310x200x100	15	0,7%	
200x150x100	349	15,8%	200x150x100
200x100x100	32	1,4%	
220x150x150	41	1,9%	
400x300x200	421	19,1%	400x300x200
450x250x200	16	0,7%	
350x200x200	67	3,0%	
500x350x200	340	15,4%	500x350x250
450x300x300	660	29,9%	
550x300x250	32	1,4%	
600x400x400	12	0,5%	
TOTAL	**2208**		

After defining the suitable size options, we addressed 4 potential suppliers and manufacturers of cardboard packaging to analyse the processes and shipments made by our company and define the solution that is most suitable from their point of view.

3 suppliers have defined the most suitable solution as the currently used type of the so-called flap-type box (Figure 2). Where to seal the box, it is necessary to stick adhesive tape at the top and bottom of the box.

Figure 2 Flap-type box

One supplier proposed a new eco-friendly and efficient solution for packaging goods in the B2C segment using cardboards with a self-locking bottom and adhesive strip (Figure 3), which does not require the use of adhesive tape.

To confirm the suitability of the solution, we compared the two solutions using the OEE metrics and DEA measurements. We have defined the persons who will carry out the test, the goods to be packaged and the conditions under which the goods will be packaged (place of packaging, place of storage of packaging material, and so on).

Figure 3 Cardboards with Self-locking bottom and adhesive strip

The warehouse manager established the OEE metrics under ideal conditions (Table 2). Working conditions are considered ideal so that the employee can perform his work as quickly as possible (the employee has no obstacles at the workplace, is not affected by external influences, has enough packaging material at his workplace).

Table 2 OEE metrics prepared by warehouse manager

Availability	Performance	Quality	OEE
89 seconds	210 seconds	0 complaints	
100%	100%	100%	100%

Subsequently, 10 measurements were taken for solution number 1 using adhesive tape (Table 3). When measuring times, many downtimes and problems caused by handling the adhesive tape and also gluing the cardboard were found. The average time in handling cardboards and adhesive tape was at 83% compared to the required time. The packaging performance itself was at 79%. The OEE indicator was at 65%, which represents a significantly reduced efficiency when working with flap-type cardboard.

Table 3 Measured OEE values for the current packaging method

	Availability (in seconds)	Performance (in seconds)	Quality (quantity)	OEE
Worker 1	112	259	0	57%
Worker 2	95	248	0	76%
Worker 3	87	223	0	96%
Worker 4	118	235	0	59%
Worker 5	91	220	0	93%
Worker 6	98	214	0	88%
Worker 7	109	315	0	39%
Worker 8	98	254	0	71%
Worker 9	135	315	0	24%
Worker 10	102	268	0	62%
Average	**104,5**	**255,1**	**0**	**65%**
%	**83%**	**79%**	**100%**	**65%**

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Solution number 2 exceeded the expectations of the sponsors (Table 4). Despite the new solution with which the staff had no previous experience, the work with the cardboard and the availability was 97% better than expected. There was a significant difference in the folding of the cardboard, as it contains a self-locking bottom, and the box is made with a single squeeze of the hand without the additional use of adhesive tape. An even bigger difference was found during the actual packaging of the shipment. Closing the cardboard by tearing off the adhesive strip will speed up the whole process and the performance has reached 102% over the required performance (performance achieved under ideal conditions with the original packaging method). The overall OEE was 98%, which is 33% higher than using the flap-type cardboard.

Table 4 Measured OEE values for the new packaging method

	Availability (in seconds)	Performance (in seconds)	Quality (quantity)	OEE
Worker 1	84	195	0	113%
Worker 2	87	204	0	105%
Worker 3	82	185	0	121%
Worker 4	102	212	0	85%
Worker 5	88	185	0	113%
Worker 6	98	214	0	88%
Worker 7	102	265	0	63%
Worker 8	79	198	0	118%
Worker 9	114	221	0	68%
Worker 10	85	185	0	117%
Average	**92,1**	**206,4**	**0**	**98%**
%	**97%**	**102%**	**100%**	**98%**

Based on the OEE model, we found that the use of cardboard with a self-locking bottom and adhesive strip used for closing the cardboard was 33% more efficient and can be used as the type of cardboard that will be demanded in the tender. Last but not least, the ecological aspect of this solution must be taken into account where polypropylene tape is not used. Thus, this solution saves the environment.

The final assignment for the tender will be a request for quotation for a 3-ply HH textured flap-type cardboard and a 3-ply HH textured cardboard with a self-locking bottom and an adhesive strip. Both types of cardboards need to be priced in 4 sizes.

In order to be able to evaluate the selection procedure, we have created a table of criteria to be evaluated. By compiling a table of evaluation criteria, we prioritised the selection of a suitable supplier. The percentage priorities were defined by the company's management according to the purchasing strategy currently defined by the company (Table 5). Invoice maturity represents 5%, speed of delivery represents 10%, EDI connectivity represents 15% and up to 70% of the decision weight will be the total cost of the purchased goods, which includes the price of the product itself, the cost of shipping and the cost of the adhesive tape needed to wrap the cardboard.

Table 5 Evaluation criteria with % importance criteria

Criterion 1	maturity of invoices	5%
Criterion 2	Costs on products	70%
Criterion 3	Speed of delivery	10%
Criterion 4	EDI communication	15%

The suppliers sent their quotations together with their business terms and conditions. An evaluation of the cost part is presented in the table below. Finally, the cost of transport is included in the price of the product for all suppliers and is therefore not included in the table (Table 6). The best offer for type 1 amounts to €2,041 and type 2 amounts to €2,134, which represents a price difference of 4.9%. Since the labour efficiency of type 2 is 33% higher, it is more efficient to use type 2 despite the seemingly higher input costs for the product itself. In light of the above information, the company decided to change the cardboard type to type 2 and thus increase the efficiency of its staff. In the long term, this is an important step for the company to solve the ever-increasing problem of securing new employees and the rising staff costs.

Table 6 Comparison of price offers

			Supplier 1		Supplier 2		Supplier 3		Supplier 4	
	Variant	Consuption (10 days)	Price	Total Price	Price	Total Price	Price	Total Price	Price	Total Price
TYPE 2 (self-locking bottom + adhesive strip)	300x200x150	238	0.55 €	131 €	0.58 €	138 €	0.49 €	117 €	0.78 €	186 €
	200x150x100	422	0.35 €	147 €	0.42 €	177 €	0.32 €	135 €	0.54 €	228 €
	400x300x200	504	0.70 €	353 €	0.67 €	338 €	0.71 €	358 €	0.98 €	494 €
	500x350x250	1044	1.54 €	1 608 €	1.83 €	1 911 €	1.46 €	1 524 €	2.11 €	2 203 €
	TOTAL			**2 238 €**		**2 563 €**		**2 134 €**		**3 110 €**
TYPE 1 (Flap box)	300x200x150	238	0.49 €	117 €	0.42 €	100 €	0.45 €	107 €	0.69 €	164 €
	200x150x100	422	0.29 €	122 €	0.25 €	106 €	0.29 €	122 €	0.49 €	207 €
	400x300x200	504	0.59 €	297 €	0.52 €	262 €	0.65 €	328 €	0.79 €	398 €
	500x350x250	1044	1.29 €	1 347 €	1.27 €	1 326 €	1.38 €	1 441 €	1.88 €	1 963 €
	duct tape	150	1.85 €	278 €	1.65 €	248 €	2.13 €	320 €	2.43 €	365 €
	TOTAL			**2 161 €**		**2 041 €**		**2 317 €**		**3 096 €**

By analysing the quotations and finally deciding to evaluate only type 2, a final comparison of the quotations can be made.

Table 7 Final comparison of business conditions

	maturity of invoices (days)	Costs on products	Speed of delivery (days)	EDI communication
	5%	70%	10%	15%
Supplier 1	60	2 238 €	30	yes
Supplier 2	60	2 563 €	14	no
Supplier 3	14	2 134 €	30	yes
Supplier 4	30	3 110 €	30	yes

A comparison of the results (Table 7) shows that the most advantageous offer is from Supplier 3, despite the fact that it does not have the best offer on invoice due date and also on speed of delivery. However, it won in the area of price and met the requirement in the area of EDI communication. Negotiations have taken place with the selected supplier regarding the signing of the contract and delivery of the goods. The company was advised that a re-analysis using OEE indicators and DEA measurements should be done 6 months after implementation to confirm the results of this study.

As part of the discussion, the question is appropriate, what did the company gain by using a new method of choosing a suitable solution and supplier? By using the original supplier selection model, companies are satisfied with choosing the offer with the most favourable price or other business conditions. Using the new method, the management of the company will get a comprehensive view of the issue of packaging goods in their company, not only by focusing on the unit price, but also on the efficiency of the solution. It emphasises the efficiency of work, which makes up an increasingly large % of the company's total costs. At the same time, it combines the efficiency of the process with the ecological aspect, which will be one of the key criteria in the future when the final consumer decides where to order the product. It is essential for the academic community to take process efficiency and ecological issues into account in their research.

5 Conclusions

The aim of the publication was to develop a new method for selecting the right solution product packaging for B2C logistics, taking into account new trends in logistics such as ecology and work efficiency. By reviewing the existing literature, we found that the authors only describe the general supply chain, taking into account common supplier evaluation indicators. However, they do not take into account the ecological and efficiency indicators of the solution.

The same number of companies focus on the unit price of the packaging material, while in an effort to reduce their costs, they also reduce the quality of the packaging materials used and thereby reduce the quality of their services. But where is the bottom of this road? The starting point is increasing the efficiency of work, as labour costs make up 20-40% of the company's total labour costs. By increasing efficiency, it is possible to achieve an increase in the quality of your services and the quality of work.

Using the OEE indicators and DEA measurements, we found that the company is using an inefficient way of packaging goods due to the incorrect use of packaging solutions. The company used this solution for several years and did not devote itself to searching for new possibilities. We therefore designed a new solution, streamlining the packaging method by 33% and reducing the number of box sizes from 14 to 4. This solution also completely eliminates the use of a polypropylene adhesive tape, which has a negative impact on the environment. The final step was to determine the most advantageous offer on the market based on the comparative method and the scoring system. By using a new method, we have increased the efficiency of packaging and therefore reduced the company's costs, increased the quality of work and thus the services provided to customers, and last but not least, we are ahead of the competition in the use of ecological packaging options and thus contribute to the sustainability of the environment. By the publication, we have achieved the stated goal and the method can be used for other companies operating in the ever-growing B2C segment.

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MULTIMODAL INTEGRATION MODEL FOR REDUCING NATIONAL LOGISTICS COSTS
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MULTIMODAL INTEGRATION MODEL FOR REDUCING NATIONAL LOGISTICS COSTS

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Keywords: logistics costs, multimodal, integration model, transportation, linear model.
Abstract: One way to minimize national logistics costs is to develop multimodal transportation. The steps for multimodal development are forming a linear model for each transportation mode, the simultaneous formation of a linear model, and forecasting and simulation of the minimum transportation costs. Area partition based on distance can be used as a solution for selecting transportation modes in multimodal with a certain distance. It can be useful in reducing transportation costs that only rely on unimodal, namely trucks. The estimation of reducing logistics costs is by forecasting goods that will pass through transportation modes in 2025 and making the simulation. Train or truck is used for short distances such as moving goods from factories or warehouses to transhipment points and from transhipment points to consumers or retailers. Trains, freighters and planes are used as the main routes as needed. The simulation results show that national logistics costs reduce by 17% when using the lowest-cost transportation mode in the area division.

1 Introduction

A country's logistics performance can be seen from the value of the logistics performance indicator (LPI). LPI is an index created by the World Bank to measure the logistics conditions of a country [1]. Table 1 shows that Indonesia's LPI rank is 46 out of 207 countries recorded by the World Bank in 2018. This ranking is below several ASEAN countries such as Singapore, Thailand, Vietnam, and Malaysia.

Table 1 LPI data for several ASEAN Region in 2018

Country	Score LPI	World Rank	ASEAN Rank
Singapore	4	7	1
Thailand	3.41	32	2
Vietnam	3.27	39	3
Malaysia	3.22	41	4
Indonesia	3.15	46	5

The poor performance of Indonesian logistics was due to the significant differences in product prices, which led to economic disparities between regions [2-6]. The high national logistics costs also show the lack of Indonesia's logistics performance. Indonesia's logistics costs currently reach 26% of the Gross Domestic Product (GDP). The logistics costs are significantly different when compared to developed countries' logistics costs i.e. Japan and the United States, which are 10.6% and 9.9% of GDP [7,8]. National logistic cost consists of transportation, administrative, and inventory costs of 12.04%, 4.52%, and 9.47% of GDP [9,10]. This cost is also higher when compared to some ASEAN countries. High logistics costs cause decreasing investors' income and move their investigation to other countries that have lower logistics costs [11].

The Indonesian government has taken various ways to minimize national logistics costs, such as minimizing dwelling time and balancing the imbalance of cargo. Nuyanto & Ngajian stated that dwelling time does not show a decrease in logistics costs. Instead, it has the potential to impose additional costs for entrusting containers to depots outside the port [12]. Priadi [13] stated that imbalanced cargo greatly impacts high logistics costs. Indonesian cargo has been getting more balanced in the last 2 years, but it does not have a significant impact on reducing national logistic cost. One

alternative to reduce national logistic cost is to minimize logistics transportation costs.

Logistics transport plays a major role in improving the country's economy [14]. Logistics transportation also affects the price of a product [14]. The comparison of transportation modes in Indonesia is 90% road transportation, less than 1% air transportation, 8% sea transportation, and 1% rail transportation [15]. Indonesia's logistics transportation is currently still dominated by unimodal, namely trucks [16]. Instead of minimizing logistic transportation costs, it is also possible to develop transportation system models integrated with other multimodal transportation modes [17]. Multimodal can reduce logistics and administrative costs because it has a single national window concept.

2 Methodology

Data used in this analysis is the distance data (km) as the independent variable (X) and cost data (in Rupiah) as the dependent variable (Y) in 2021. The data analyzed is using one dry container (2TEUs). Transportation modes compared are trains, freighters, roll on roll off (RORO) ships, and trucks. The data of train, freighter and RORO are taken from State-Owned Companies and truck data are from Private Companies. The aeroplane is not used as one of the parameters due to the high cost and cannot much loading of goods much, so it is used as an exclusive alternative for sending small goods and fast time [18-20].

The data are formed into a linear model for each mode using ordinary least squares (OLS) [21]. The linear model function is (1)

$$Y_{nx1} = X_{nxk}\beta_{kx1} + \varepsilon_{nx1} \quad (1)$$

The linear model assumption is

$$E(\varepsilon) = 0, E(\varepsilon\varepsilon') = \sigma^2 I_n$$

Calculate the sum square of the error

$$\begin{aligned} e'e = \; & (Y - X\hat{\beta})'(Y - X\hat{\beta}) \\ & = Y'Y - \hat{\beta}'X'Y - Y'X\hat{\beta} + \hat{\beta}'X'X\hat{\beta} \\ & \Rightarrow e'e = Y'Y - 2\hat{\beta}'X'Y + \hat{\beta}'X'X\hat{\beta} \end{aligned}$$

with $\hat{\beta}$ is the estimator of β. The way to minimize $\hat{\beta}$ is make condition the first derivative of the sum square error $e'e$ to be zero

$$\begin{aligned} \frac{\partial}{\partial\hat{\beta}}(e'e) = 0 \Rightarrow -2X'Y + 2X'X\hat{\beta} = 0 \\ \Rightarrow X'X\hat{\beta} = X'Y \end{aligned}$$

OLS estimator of β (2)

$$\hat{\beta} = (X'X)^{-1}X'Y \quad (2)$$

The significant impact of the independent variable on the dependent variable can be seen if the regression p-value is less than 0.05 [22]. If the independent variable has been proven to affect the dependent variable, then it can be seen the amount of influence of the independent variable on the dependent variable by using $\boldsymbol{R^2}$. $\boldsymbol{R^2}$ is used as measure of model fit [23-25]. The function of $\boldsymbol{R^2}$ is (3)

$$R^2 = \frac{V_{n=1}^{N}\hat{y}_n}{V_{n=1}^{N}y_n} \quad (3)$$

where $V_{n=1}^{N}\hat{y}_n$ is residual variance and $V_{n=1}^{N}y_n = \frac{1}{N-1}\sum_{n=1}^{N}(y_n - \bar{y})^2$. R^2 which is more than 60% indicates that the independent variable has a dominant role in influencing the dependent variable. The rest is explained by other variables [26,27].

After the significant regression test, it is continued by forming the model simultaneously. Each mode of transportation model is formed in a linear line with abscissa axes in the form of a distance from 0 to 2200 km. This distance is the estimated length of the longest island (Sumatra) in Indonesia, which is 2194 km. Ordinate axes result from a linear model of each mode of transportation. The point of intersection is used as a boundary to divide the order of transportation modes that should be used.

The calculation of the cheapest route is done after getting a linear model. The cost of transportation with the cheapest mode of transportation is calculated by calculating the minimum transportation costs and the cost of moving goods [19]. The network model and mathematical formulation is (4):

$$\begin{aligned} \min Z = \textstyle\sum_{i\in 1}\sum_{j\in A_{\bar{i}}}\sum_{k\in J} c_{ij}^{k}x_{ij}^{k} + \\ \textstyle\sum_{i\in v}\sum_{j\in A_{\bar{i}}}\sum_{\mathrm{k}\in J} c_{i}^{kl}r_{i}^{kl} \end{aligned} \quad (4)$$

where

c_{ij}^{k} = The transport cost from node i to node j by choosing k transport

x_{ij}^{k}

$= \begin{cases} 1, & \text{From node } i \text{ to node } j \text{ select the } k \text{ transport mode} \\ 0, & \text{From node } i \text{ to node } j \text{ select another transport mode} \end{cases}$

c_{i}^{kl} = The conversion cost from the k transport mode to the l transport mode at node i

r_{i}^{kl}

$= \begin{cases} 1, & \text{At node } i, \text{ switch from the } k \text{ tran. m. to the } l \text{ tran. m.} \\ 0, & \text{No change of transport mode occurs at node } i. \end{cases}$

A_{i}^{-} =The set of nodes pointed by the arc starting from node i connected to node i

A_{i}^{+} = The set of nodes, at the end of the arc that is connected to node i and points to node i

V = The collection of all nodes in the network

0 = The starting node of the network

D = the termination node of the network

I = the collection of all intermediate nodes in the network
$\boldsymbol{J}$ = collection of all modes of transportation

The calculation of the cheapest route is carried out on the island of Java because the complete mode of transportation is on the island of Java. Calculations were carried out in 4 simulations, consisting of Cikarang Dry Port – Tanjung Mas Semarang, Cikarang Dry Port – Tanjung Perak Surabaya, Tanjung Priok Jakarta – Tanjung Perak Surabaya, and Tanjung Perak Surabaya – Tanjung Priok Jakarta.

After the simulation is done by getting the cheapest route, then the right transportation mode is obtained as the main haul in multimodal. The multimodal transportation system in Indonesia is expected to be realized in 2025 based on the presidential decree [4]. Therefore, an estimation of the amount of movement of goods in Java will be carried out in 2025.

Forecasting methods used are simple moving average (SMA) and double exponential smoothing (DES). SMA indicator is by calculating the average historical data. SMA indicator at the *t*-th time step with a historical data size of *m* can be formulated as (5)

$$SMA_m^t = \frac{\sum_{u=1}^{m} p_{t-u+1}}{m} \tag{5}$$

with $\boldsymbol{p_u}$ is the data of the *u*-th time step [28]. The results of the fitting will be used as a basis for forecasting the following year.

DES is a time series forecasting method if there is a trend in data patterns [29, 30]. The modelling algorithm is (6):

(i) Determine $S'_t = \theta P_t + (1-\theta)P'_{t-1}$
(ii) Determine $S''_t = \theta P_t + (1-\theta)P''_{t-1}$
(iii) Determine $\gamma_t = 2S't - S''_t$
(iv) Determine $\varphi_t = \frac{\gamma_t}{1-\gamma_t}(S'_t - S''_t)$
(v) Then $S_{t+z} = \gamma_t + \varphi_t z$ (6)

The best model comparison between SMA and DES is by comparing the smallest mean absolute percentage error (MAPE), mean absolute deviation (MAD), and mean square deviation (MSD) [31]. The functions of MAPE, MAD, and MSD are (7), (8), (9)

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|P_t - \hat{P}_t|}{P_t} \tag{7}$$

$$MAD = \frac{1}{n}\sum_{t=1}^{n}|P_t - \hat{P}_t| \tag{8}$$

$$MSD = \frac{1}{n}\sum_{t=1}^{n}(P_t - \hat{P}_t)^2 \tag{9}$$

The last step is the estimation of national logistics costs through the multimodal model to see the reduction in logistics costs after the multimodal model is applied.

3 Result and discussion

The data is presented descriptively in the form of a scatter plot, as shown in Figure 1. Figure 1 shows that the distance data forms a linear pattern of costs for each mode of transportation. Figure 1 shows that there are very few train lines in Indonesia. There are only six destination stations for cargo trains in Indonesia. After a linear pattern is seen, a linear model is formed using ordinary least squares (OLS).
Linear model of RORO is (10)

$$Y_{\text{roro}} = 10828600 + 11457X_{\text{roro}} \tag{10}$$

Linear model of freighter is (11)

$$Y_{\text{freighter}} = 2617045 + 1828X_{\text{freighter}} \tag{11}$$

Linear model of train is (12)

$$Y_{train} = 702216 + 3253X_{train} \tag{12}$$

Linear model of truck is (13)

$$Y_{truck} = 1448726 + 16368X_{truck} \tag{13}$$

P-value and coefficient of determination R^2 for each mode of transportation are shown in Table 2. The p-value for each mode is less than 0.05. The p-value indicates that the distance of each transportation mode has a significant effect on costs. The magnitude of the effect of distance on costs can be seen using the coefficient of determination R^2. R^2 for each transportation, mode is above 60%. P-value and R^2 shows that distance affects the cost of each mode of transportation significantly. Furthermore, a linear model is formed with the abscissa axes (X) in the form of a distance from 0 to 2200 to create a model simultaneously.

Table 2 P-value and R^2 for each transportation mode

Indicator	Transportation Mode			
	Truck	Train	Roro	Freighter
p-value	0.000	0.010	0.000	0.000
R^2	95.51%	81.60%	77.66%	70.15%

Figure 2 shows that there are 3 points of intersection on the abscissa axes (80, 1344, and 1910). The third intersection point is not used as a parameter because it is at a high-cost coordinate. The area is divided into three areas, according to Figure 2. Area 1 is a transportation distance of less than 80 km ($X \leq 80$). Area 2 is a transportation distance between 80 km and 1344 km ($80 < X \leq 1344$). Area 3 is a transportation distance above of 1344 km ($X > 1344$).

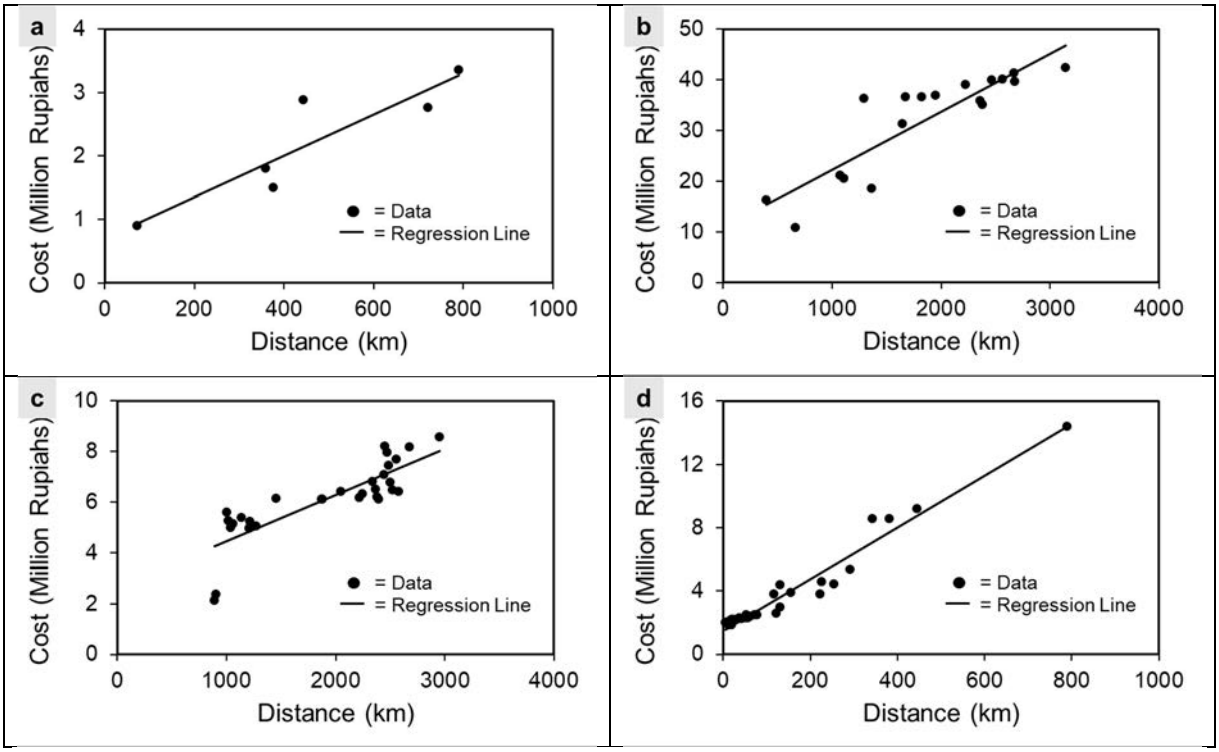

Figure 1 Scatter plot between distance vs cost in transportation modes (a) Train, (b) Roro, (c) Freighter, and (d) Truck

Area 1 shows that the train is the cheapest mode of transportation, so the train is the first alternative for the main transportation. However, not all areas have access to trains. The construction of railway lines and the procurement of trains take a long time and have high costs. So in Area 1, trucks can be used as an alternative to trains. Freighter and Roro cannot be recommended because of the high cost of short-distance transportation.

The cheapest mode of transportation for Area 2 is the train. The intermediate distance in Area 2 is between 80 km and 1344 km. The train can be used as a main haul for transportation within the island at medium distances. The second cheapest mode of transportation for Area 2 is the freighter. Freighter can be used as another alternative solution for inter-island transportation modes with medium distances.

The cheapest mode of transportation for Area 3 is the freighter. If the distance is within the island, then the train can be used as an alternative other than the freighter.

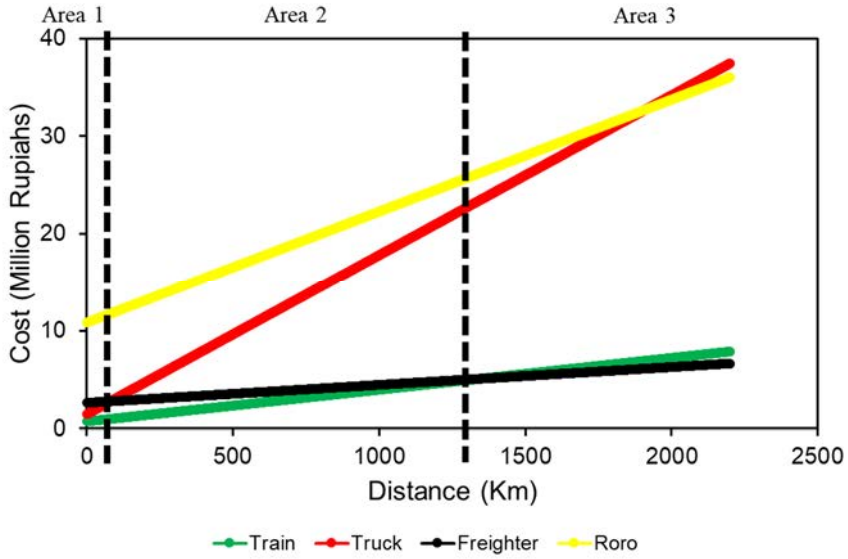

Figure 2 Linear model for simultaneous modes of transportation

The results of the combined linear models are summarized in Table 3. Each area has a choice of transportation costs from very low to very high. The cheapest mode of transportation for short distances is train and truck. The cheapest mode of transportation for medium distances is the train and freighter. The cheapest mode of transportation for long distances is freighter and train.

Table 3 Transportation cost options for each area

Transportation Cost	Area 1 ($X \leq 80$)	Area 2 ($80 < X \leq 1344$)	Area 3 ($X > 1344$)
Very Low	Train	Train	Freighter
Low	Truck	Freighter	Train
High	Freighter	Truck	Truck / Roro
Very High	Roro	Roro	

These results are in accordance with the results of other studies [19,32,33]. This is due to the lower operating costs of trains and trucks compared to freighters at short distances [31].

Train or truck is used for short distances such as moving goods from factories or warehouses to transhipment points and from transhipment points to consumers or retailers. Train, freighters, and aeroplanes are used as the main haul depending on needs.

The linear model simulation is carried out in Java because only Java has complete transportation. The distance to the island of Java is less than 1000 km (medium distance). Table 4 is a simulation result where the train is the cheapest mode of transportation, and the freighter is the alternative transportation. The train can be the main haul in multimodal, and freighter is the alternative mode. The result is in accordance with the results of the formation of a simultaneous linear model.

Table 4 Delivery of goods simulation

Distance (Km)	Route	Track	Cost (Million Rupiahs)	Transportation
481	Cikarang Dry Port – Tanjung Mas Semarang	Cikarang Dry Port – Tanjung Mas Semarang	2.34	Train
		Cikarang Dry Port – Tanjung Priok Jakarta (transit) Tanjung Priok Jakarta – Tanjung Mas Semarang	3.78	Train (transit) Train
		Cikarang Dry Port – Tanjung Priok Jakarta (transit) Tanjung Priok Jakarta – Tanjung Mas Semarang	4.40	Train (transit) Freighter
753	Cikarang Dry Port – Tanjung Perak Surabaya	Cikarang Dry Port – Tanjung Perak Surabaya	2.76	Train
		Cikarang Dry Port – Tanjung Priok Jakarta (transit) Tanjung Priok Jakarta – Tanjung Perak Surabaya	4.26	Train (transit) Train
		Cikarang Dry Port – Tanjung Priok Jakarta (transit) Tanjung Priok Jakarta – Tanjung Perak Surabaya	4.96	Train (transit) Freighter
788	Tanjung Priok Jakarta – Tanjung Perak Surabaya	Tanjung Priok Jakarta – Tanjung Perak Surabaya	2.76	Train
		Tanjung Priok Jakarta – Tanjung Perak Surabaya	4.26	Freighter
		Cikarang Dry Port – Tanjung Priok Jakarta (transit) Tanjung Priok Jakarta – Tanjung Perak Surabaya	4.96	Train (transit) Train
	Tanjung Perak Surabaya – Tanjung Priok Jakarta	Tanjung Perak Surabaya – Tanjung Priok Jakarta	3.06	Train
		Tanjung Perak Surabaya – Tanjung Priok Jakarta	4.06	Freighter
		Tanjung Perak Surabaya – Tanjung Mas Semarang (Transit) Tanjung Priok Jakarta – Tanjung Perak Surabaya	4.41	Train (transit) Train

SMA (2) and DES prediction methods are used to predict the number of goods passing through all modes of transportation in 2025 based on data from the Central Statistics Agency from 2007 to 2021 [34]. The fitting results for data on the number of goods passing through transportation are shown in Figure 3. Figure 3 shows that

fitting with the DES method produces a graph that is close to the original data. This prediction is reinforced by the smallest MAPE, MAD, and MSD values in the DES model, as shown in Table 5.

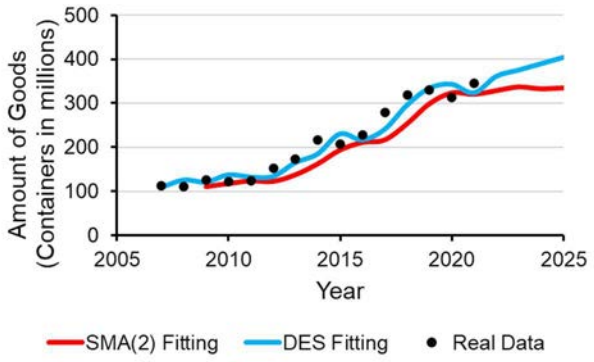

Figure 3 Data on the number of goods through transportation modes from 2007-2021 and fitting results from SMA (2) and DES prediction methods

Table 5 Measures of the accuracy of the fitted model

Measures of Accuracy	DES	SMA(2)
MAPE	8.36	9.75
MAD	1.71×10^{7}	2.25×10^{7}
MSD	4.06×10^{14}	9.63×10^{14}

The forecast results for the number of goods that pass through all modes of transportation using the DES method in 2025 are 404635322 containers.

The island of Java is the centre of the movement of goods in Indonesia, especially the Jakarta and East Java areas. Jakarta supplies western Indonesia, and East Java supplies eastern Indonesia [35, 36]. The transportation mode used from Jakarta to East Java or vice versa is dominated by unimodal, namely trucks [37]. The distance between Jakarta and East Java is about 800 km (medium distance). The number of goods in 2025 is divided into four conditions for travel from Jakarta to East Java. The result is that logistics costs decrease to 17% of GDP when using trains. It can be seen in Table 6.

Table 6 National logistic cost estimation

No	Condition	National Logistic Cost Estimation (%GDP)
1	90% truck, 4.5% freighter, 4.5% roro, and 1% train	73.96%
2	100% train	17.23%
3	100% freighter	21.99%
4	50% train, 40% freighter, and 10% truck	25.28%

4 Conclusions

The multimodal integration model in logistics transportation is an effective model for reducing national logistics costs. Transportation cost options are selected based on distance. Short distances are more efficient using trains and trucks as an alternative. Short distances are used for moving goods from factories or warehouses to transhipment points and from transhipment points to consumers or retailers. Medium distance is more efficient using train and freighter as an alternative. Long distances are more efficient using freighter and train as an alternative. Medium and long distances are used as the main haul in multimodal. The application of the unimodal to multimodal transportation model can reduce national logistics costs to 17% in 2025.

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