ECOLOGICAL SOLUTION OF GOODS PACKAGING FOR B2C LOGISTICS

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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.

ECOLOGICAL SOLUTION OF GOODS PACKAGING FOR B2C LOGISTICS
Karol Kvak

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%**

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

	Variant	Consuption (10 days)	Supplier 1 Price	Supplier 1 Total Price	Supplier 2 Price	Supplier 2 Total Price	Supplier 3 Price	Supplier 3 Total Price	Supplier 4 Price	Supplier 4 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 €

ECOLOGICAL SOLUTION OF GOODS PACKAGING FOR B2C LOGISTICS
Karol Kvak

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.

References

[1] MAJTAN, Š.: *Nákup a riadenie zásob*, Bratislava, SPRINT, 2005. (Original in Slovak)
[2] MAJDUCHOVA, H., NEUMANNOVA, A.: *Podnikove hospodarstvo pre manažérov*, Bratislava, Iura Edition, 2008. (Original in Slovak)
[3] SYNEK, M.: *Manažérska ekonomika*, Praha, Grada Publishing, 1996. (Original in Czech)
[4] ELODIE, A., NANTAPORN, R.: *Consignment contracts with retail competition*, Mechanical and Industrial Engineering, University of Illinois, Chicago, United States, 2011.
[5] GUNASEKARAN, A., SPALANZANI, A.: Sustainability of manufacturing and services: Investigations for research and applications, *International Journal of Production Economics*, Vol. 140, No. 1, pp. 35-47, 2012. https://doi.org/10.1016/j.ijpe.2011.05.011
[6] SONAR, H., GUNASEKARAN, A., AGRAWAL, S., ROY, M.: Role of lean, agile, resilient, green, and sustainable paradigm in supplier selection, *Cleaner Logistics and Supply Chain*, Vol. 4, No. July, pp. 1-10, 2022. https://doi.org/10.1016/j.clscn.2022.100059

[7] LUKIC, R.: The effects of application of lean concept in retail, *Economia, Seria Management*, Vol. 15, No. 1, pp. 88-98, 2012.

[8] VORKAPIC, M.: Applicability of the lean concept to the management of small-scale manufacturing enterprises in Serbia, *Tehnicki Vjesnik - Technical Gazette*, Vol. 24, No. 6, pp. 1929-1934, 2017.

[9] TSAI, W.C.: Fuzzy measures of supplier evaluation under lean concepts, *Journal of the Operational Research Society*, Vol. 60, No. 7, pp. 1005-1011, 2009.

[10] CARVALHO, H.: Trade-offs among Lean, Agile, Resilient and Green Paradigms in Supply Chain Management: A Case Study Approach, *Lecture Notes in Electrical Engineering*, Vol. 242, No. 2, pp. 953-968, 2014.

[11] GUO, Y., XU, Z.: *A Model of Lean Supplier Management Based on the Lean Production*, Research and Practical Issues of Enterprise Information Systems II, Vol. 254, pp. 717-726, 2007. https://doi.org/10.1007/978-0-387-75902-9_81

[12] YANG, Y.: *Grey entropy method for green supplier selection*, International Conference on Wireless Communications, Networking and Mobile Computing, 2007.

[13] DURSUN, M.: Agile supplier evaluation using hierarchical TOPSIS method, WSEAS TRANSACTIONS on INFORMATION SCIENCE and APPLICATIONS, Vol. 18, pp. 12-19, 2021.

[14] DOTOLI, M..: *Integrated supplier selection and order allocation under uncertainty in agile supply chains*, IEEE International Conference on Emerging Technologies and Factory Automation, ETFA, pp. 1-6, 2015.

[15] CABRAL, I., ESPADINHA-CRUZ, P., GRILO, A.C.B.: Decision-making models for interoperable Lean, Agile Resilient and Green Supply Chains, 11th International Symposium on the AHP, Naples, Italy, pp. 1-6, 2011.

[16] GHAHREMANLOO, H., TAROKH, M.J.: *An integrated multi agent based model to find the most agile supplier*, 2011 IEEE International Conference on Industrial Engineering and Engineering Management, pp. 514-518, 2011.

[17] MISHRA, S., SAMANTRA, Ch., DATTA, S., MAHAPATRA, S.S.: Supplier evaluation in agile supply chain in fuzzy paradigm, *International Journal of Services and Operations Management*, Vol. 16, No. 1, pp. 1-41, 2013.

[18] TORABI, S.A., BAGHERSAD, M., MANSOURI, S.A.: Resilient supplier selection and order allocation under operational and disruption risks, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 79, pp. 22-48, 2015. https://doi.org/10.1016/j.tre.2015.03.005

[19] HALDAR, A., RAY, A., BANERJEE, D., GHOSH, S.: A hybrid MCDM model for resilient supplier selection, *International Journal of Management Science and Engineering Management*, Vol. 7, No. 4, pp. 284-292, 2012. https://doi.org/10.1080/17509653.2012.10671234

[20] STRAKA, M.: *Distribution and Supply Logistics,* Cambridge Scholars Publishing, Newcastle upon Tyne, United Kingdom, 2019.

[21] PRAMANIK, D., HALDAR, A., MONDAL, S.Ch., NASKAR, S.K., RAY, A.: Resilient supplier selection using AHP-TOPSIS-QFD under a fuzzy environment, *International Journal of Management Science and Engineering Management*, Vol. 12, No. 1, pp. 45-54, 2017. https://doi.org/10.1080/17509653.2015.1101719

[22] HOSSEINI, S., KHALED, A.A.: A hybrid ensemble and AHP approach for resilient supplier selection, *Journal of Intelligent Manufacturing*, Vol. 30, No. 1, pp. 207-228, 2019.

[23] KANNAN, D., GOVINDAN, K., RAJENDRAN, S.: Fuzzy axiomatic design approach based green supplier selection: a case study from singapore, *Journal of Cleaner Production*, Vol. 96, pp. 194-208, 2015. https://doi.org/10.1016/j.jclepro.2013.12.076

[24] MABROUK, N.B.: Green supplier selection using fuzzy Delphi method for developing sustainable supply chain, *Decision Science Letters*, Vol. 10, No. 1, pp. 63-70, 2021.

[25] LEE, J., CHO, H., KIM, Y.S.: Assessing business impacts of agility criterion and order allocation strategy in multi-criteria supplier selection, *Expert Systems with Applications*, Vol. 42, No. 3, pp. 1136-1148, 2015. https://doi.org/10.1016/j.eswa.2014.08.041

[26] HAMDAN, S., CHEAITOU, A.: *Green supplier selection and order allocation using an integrated fuzzy TOPSIS, AHP and IP approach*, IEOM 2015 - 5th International Conference on Industrial Engineering and Operations Management, pp. 1-10, 2015.

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