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APPROACH TO OPTIMISING AND MANAGING WAREHOUSE STOCKS IN A CAR SERVICE

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Abstract. The automotive service industry is characterised by a high degree of complexity and dynamism in its logistics processes. A pivotal challenge confronting the organisation is the effective management of inventory. The maintenance of optimal inventory levels is of paramount importance in ensuring uninterrupted service and minimising the costs associated with storage and delivery. Inventory management is an intricate process that extends beyond the mere maintenance of availability. It necessitates the strategic decision-making process concerning supplier selection, order planning, and resource allocation over time. *The present study proposes* a model for inventory management in automotive service stations that reflects the complexity of real-world operating conditions. The model incorporates a multitude of suppliers, each exhibiting distinct pricing structures and delivery terms. Constraints are imposed on the selection of suppliers, thereby influencing the overall dynamics of the supply chain. It is important to note that a particular auto part may be available from more than one supplier, with unit prices varying across suppliers and over time. The model operates under the assumption that the demand for each part for each period is known in advance, as are the storage costs, the lower and upper limits on inventory levels, the supplier-specific order quantity constraints, and the initial inventory level at the beginning of the planning horizon. *The objective* of the proposed model is to minimise the total inventory costs, including purchasing, holding, and potential shortage costs, by applying integer linear programming techniques. The problem is formulated with decision variables representing quantities to be ordered and stocked, and includes a set of linear constraints reflecting all operational requirements. In order to enhance computational efficiency, the model employs heuristic methods to identify high-quality approximate solutions within acceptable time frames. This approach is of particular value in applications where the dimensionality of the problem and the number of suppliers can significantly increase the computational complexity. Empirical evidence has demonstrated the potential of the model to enhance inventory management in practical scenarios. The primary benefits observed include a reduction in overall costs, enhanced delivery coordination, and increased flexibility in inventory planning. These improvements contribute to enhanced operational efficiency and increased competitiveness for automotive service providers. It is recommended that future research concentrate on extending the model to incorporate further real-world factors, including lead times, demand variability, and the capacity to return excess components to suppliers. Moreover, the examination and comparison of disparate inventory management strategies under varying conditions has the potential to yield valuable insights for the optimisation of service operations. *In conclusion*, the proposed mathematical framework provides an effective tool for the optimisation of inventory procurement and storage processes in automotive service providers. The integration of the precision afforded by linear optimisation with the adaptability of heuristic methodologies signifies the model's practical relevance within contemporary business contexts, wherein enhancing resource efficiency is a pivotal factor in achieving success.

Keywords: optimise, inventory management, suppliers, warehouse, auto repair shop, auto parts.

JEL Classification: L90, L91, L62, R48

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1. Introduction

In the contemporary era, characterised by rapid technological development, escalating consumer demands and an accelerating business pace, effective supply chain management has emerged as a pivotal factor in the success of any business (Azimov et al., 2024; Kholodenko & Gusak, 2022; Nykyforov et al., 2020; Nikolova-Alexieva et al., 2022; Shopova et al., 2024). This is of particular pertinence to the automotive industry, where the constant evolution of models and technologies necessitates a high degree of flexibility and precision in planning and inventory management. A multitude of variables must be taken into consideration when planning the purchase of auto parts. These include variations in the price of parts, different suppliers, fluctuations in the demand for auto parts, as well as storage costs. Consequently, identifying the optimal purchasing strategy can become a complicated task. In this context, the mathematical model is a powerful tool that can provide a structured and systemic approach to the problem. Mathematical models provide methodologies for the resolution of complex issues by employing rigorous logic and enabling the user to identify the optimal solution from a multitude of potential options. These instruments are extensively employed in the domain of automobile insurance, wherein products such as civil liability insurance are intimately associated with the serviceability of automobiles (Raeva & Pavlov, 2017; Raeva, Pavlov & Georgieva, 2021). Similar applications can be observed in other domains, including finance (Georgiev & Vulkov, 2021A; Georgiev & Vulkov, 2021B; Georgiev & Todorov, 2023). These models can be utilised for the analysis of various scenarios, facilitating the formulation of well-informed decisions by considering all pertinent factors and restrictions. The present paper examines one such issue.

2. Research Problem

A significant challenge confronting automotive service providers pertains to the orchestration of operations and the maximisation of resource utilisation (time, human capital, materials). The utilisation of mathematical models has been identified as a potential solution to this issue, with the capability to facilitate more efficient resource planning and optimisation of work processes (Fapetu & Akinola, 2008; Nurprihatin, Regina & Rembulan, 2021; Shen, Zuo-Jun M. et al., 2019; Naoum-Sawaya et al., 2015; Sundstrom & Binding, 2011; Ma et al., 2018). A multitude of issues must be addressed in order to optimise the operation of a car service. Some of them are as follows:

1) Investing in an appropriate technology. Modern automobiles are characterised by a high degree of technological sophistication, with a multitude of electronic components and sensors being integral to their functionality. In order to guarantee a quality and efficient repair service, car services must invest in appropriate technologies and tools. This encompasses diagnostic scanners, tyre balancing and mounting devices, engine repair machines, computer programs, and other related equipment.

2) Management of inventory. The optimisation of inventory management has been demonstrated to reduce downtime due to a lack of required parts. Repair shops can utilise inventory management software to assist with the maintenance of records pertaining to inventory, the prediction of future requirements, and the timely ordering of materials.

3) Work distribution. The effective scheduling of technicians' working hours has been demonstrated to reduce customer waiting times and ensure the timely completion of all tasks. The utilisation of time scheduling software has been demonstrated to assist in the mitigation of technician overload, thereby ensuring the optimal utilisation of their skills.

4) Customising the services. Clients have been shown to have a preference for customised services. Car services can offer a highly personalised service that includes pre-registration of customers, additional services such as car shipments for repairs and car deliveries, and they can also offer loyalty programs and rewards for frequent customers.

5) Marketing. Marketing can be used to attract new clients and increase sales. It is evident that car services have the capacity to utilise a variety of marketing methodologies.

6) Investing in modern equipment and tools. The integration of innovative technologies and equipment has been demonstrated to have a substantial impact on the acceleration of work processes and the enhancement of service quality.

7) Providing vocational training. The implementation of regular personnel training is instrumental in ensuring that all employees within the car service are competent and proficient in their respective domains.

8) Using software for car service management. Technological advances allow software to be used that optimises work processes in car services, manages mechanics' work schedules, stores and analyses client data, and much more.

9) Creating an inventory management system. The organisation of the inventory of automobile parts and accessories facilitates the expeditious procurement of the requisite materials for the automotive repair process.

10) Building good relationships with clients. The provision of quality servicing and attention to clients is of crucial importance for attracting and retaining the trust of clients.

11) Optimising the appointment booking systems. The utilisation of an online appointment booking system has the potential to enhance the efficiency of the client booking process and facilitate the management of staff schedules.

12) These are just a few ideas for optimising workflow in a car repair shop. Attention to detail and the context of the car repair shop can lead to new and useful ideas for improving the workflow.

One of the most significant issues that has been identified pertains to the realm of inventory management within the context of automotive service provision. This encompasses the presentation of the pertinent circumstances, encompassing the number and stipulations pertaining to suppliers, the requisite automobile components, and the constraints imposed by inventory storage. Utilising the mathematical model proposed, we will examine the optimisation of inventory management in various scenarios. In addition, the model's recommendations for decision-making, purchasing parts, and selecting suppliers will be identified. The results of the analysis of each situation will demonstrate the potential application of the mathematical model in assisting car services to reduce general costs.

The inventory management problem can be described as follows: there is a requirement for a number of automobile parts to be available at the car service. Each component may be procured from one or multiple suppliers, each of whom sets its own price and conditions. The objective is to ascertain the quantity of each component to be procured and the supplier, with a view to minimising general costs (including purchasing and storage) while satisfying specific constraints (e.g., the necessity to maintain minimum levels of stock or restrictions on storage space).

The solution to this problem is presented in the form of a mathematical model based on the methods of integer linear programming. The model incorporates the solution of an objective function, which represents the total cost of procuring and storing the auto parts. The model constraints reflect the multifarious aspects of the problem, including the auto parts needs, storage restrictions and supplier conditions.

The employment of an integer linear programming model facilitates the efficient resolution of problems through the utilisation of conventional optimisation algorithms. Notwithstanding the intricacy of the problem, the model facilitates an accurate and efficient solution that can be utilised to make operational decisions in the automotive workshop.

3. Mathematics

A particular category of automobile components may be procured from multiple suppliers (m). For a specified number of subsequent periods (n), the price of this component is subject to variation, both with respect to the supplier and the period during which the order is placed (cij). For each designated period, the quantity of automotive components (di) scheduled for utilisation during the specified timeframe is known. This information can be obtained through either proactive planning or through the analysis of statistical data, which is processed in advance using appropriate software (Raeva, Mihova & Nikolaev, 2019). The price for storing one auto part during this period (hi), the minimum and maximum quantity of auto parts (Li and Ui), which need to be stored, as well as the minimum and maximum quantity of auto parts ($M1_{ij}$ and $M2_{ij}$), which can be purchased from the respective supplier for this period are also known. The quantity of car parts (s0) available at the car service centre at the start of the planning process is also known. It is necessary to plan which supplier and for which period can provide the purchase of a certain number of parts of a given type (xij) so that the total cost (Z) is minimal. In addition, it is required to determine the number of spare parts to be stored in the car service centre (si) for each period.

The following values are entered:

1) Input parameters:

n – number of periods;

m – number of suppliers;

s_0 – the number of auto parts at the beginning, i.e., the availability of stocks in the warehouse before the first period;

d_i – the parts needed during the i^{-st} period, $i=\overline{1,n}$;

c_{ij} – price of one auto part during the i^{-st} period from j^{-th} supplier, $i=\overline{1,n}, j=\overline{1,m}$;

h_i – price for storing one part during i^{-th} period, $i=\overline{1,n}$;

L_i – minimum quantity of auto parts (number) in stock during i^{-th} period, $i=\overline{1,n}$;

U_i – maximum number of auto parts (number) in stock during i^{-th} period, $i=\overline{1,n}$;

M_{ij}^1 – minimum quantity of auto parts (number), which can be purchased during i^{-th} period from j^{-th} supplier, $i=\overline{1,n}, j=\overline{1,m}$;

M_{ij}^2 – maximum quantity of auto parts (number), to be purchased during i^{-th} period from j^{-th} supplier, $i=\overline{1,n}, j=\overline{1,m}$.

2) Unknown (to be determined) variables:

x_{ij} – number of auto parts to be purchased during i^{-th} period from j^{-th} supplier, $i=\overline{1,n}, j=\overline{1,m}$;

s_i – number of auto parts to be in stock during i^{-th} period, $i=\overline{1,n}$;

For solving the problem set the following integer linear optimisation model is suggested (1)-(10):

$$\min Z=\sum_{i=1}^{n}\sum_{j=1}^{m}c_{ij}x_{ij}+\sum_{i=1}^{n}h_i s_i \quad (1)$$

$$s_i=s_{i-1}+\sum_{j=1}^{m}x_{ij}-d_i,\ \forall i=\overline{1,n} \quad (2)$$

$$M_{ij}^{1}\le x_{ij},\ \forall i=\overline{1,n},\forall j=\overline{1,m} \quad (3)$$

$$x_{ij}\le M_{ij}^{2},\ \forall i=\overline{1,n},\forall j=\overline{1,m} \quad (4)$$

$$L_i\le s_i,\forall i=\overline{1,n} \quad (5)$$

$$s_i\le U_i,\ \forall i=\overline{1,n} \quad (6)$$

$$x_{ij}\ge 0,\forall i=\overline{1,n},\forall j=\overline{1,m} \quad (7)$$

$$s_i\ge 0,\forall i=\overline{1,n} \quad (8)$$

$$x_{ij}\in Z,\forall i=\overline{1,n},\forall j=\overline{1,m} \quad (9)$$

$$s_i\in Z,\forall i=\overline{1,n}, \quad (10)$$

In this model (1)-(10), (1) denotes the objective function. This is the total cost of procuring and storing the auto parts. Constraint (2) is concerned with achieving equilibrium. The quantities available during the specified period are presented as the sum total of those available in the previous period, those purchased during the current period, and those that will be used during the current period, minus the quantities that will be used during the current period. Constraints (3) and (4) correspond with the fact that a minimum and maximum quantity of auto parts that can be purchased from the respective supplier for the given period is imposed. Constraints (5) and (6) ensure that the minimum and maximum quantities of auto parts to be stored for the given period are guaranteed. It is evident that inequalities (7) and (8) ensure the non-negativity of variables (given that variables are real quantities), while constraints (9) and (10) represent integer requirements for the unknowns (it is a well-known fact that the number of auto parts are integers) (Georgiev et al., 2020; Georgiev et al., 2022; Grozev et al., 2022; Wilson, 2015).

Models (1) - (10) constitute a problem of integer linear optimisation. It is acknowledged that such problems are classified as NP-complete (non-deterministic polynomial time). In such a class of problems, even with relatively modest values, it is acknowledged that the time required to identify the correct solutions may be unacceptably long, even when employing advanced computing resources and specialized software. In the present paper, a proprietary programme code is presented in MATLAB R2021, which leads to solving problem (1)-(10) based on heuristics techniques. It has been demonstrated that heuristic techniques for optimisation do not invariably result in the optimal solution to the problem. It is evident that the solutions obtained frequently deviate from the optimal by a maximum of 5%. However, it should be noted that the time required to identify such solutions is deemed to be within an acceptable range.

The mathematical model proposed in the paper constitutes a targeted approach to the resolution of complex and realistic problems in the field of optimising the procurement and storage of auto parts. The intricacy and mutable character of such issues, coupled with the volatility of prices, constraints in quantity, and the presence of disparate suppliers, underscores the indispensability of a model that can effectively address these challenges.

As outlined above, the proposed mathematical model has the potential to make a substantial contribution to the optimisation of the processes involved in the purchasing and storing of auto parts, thereby enhancing the efficiency and profitability of these operations.

4. Numerical Examples

Automobile car services are required to formulate a strategy for the supply of spare parts within a 12-month period. It is vital to ensure that a continuous process of services and repairs is maintained.

In this particular case study, the focus will be on a medium-sized car service operating within the city of Ruse. The planning for the purchase quantities refers to a specific part in the case of the timing belt (for Peugeot with engine 1.2, 60 kW), which is one of the most commonly used parts. As illustrated in Table 1, the following data set contains the prices of one belt for the subsequent 12 months. The data set comprises periods from three suppliers. The prices (in BGN) vary according to the month, due to the fact that the producers update their prices at regular intervals (a month, a quarter, half a year, etc.).

The following Table 2 shows the minimum volumes that can be procured by each supplier in the specified months.

In the next Table 3, the minimal quantities, which can be purchased by each supplier for the months identified.

Table 4 shows the approximate number of tapes that will be used in the repair work, the minimum and maximum quantities to store, and the cost of storing one tape for one month.

In the beginning the car repair car shop possesses 4 belts.

With the given solution, the total costs are BGN 15897.6 lv.

The model provides significant contributions in several key areas:

1. Integer linear optimisation. The model employs integer linear optimisation, a sophisticated tool for modelling actual problems. It is evident that this enables the modelling of situations in which the variables can be integers, as evidenced by the example of the auto parts. The mathematical constraints permit the precise limitation of the variables, thereby ensuring that the realistic constraints are reflected in practice.

2. A precise balance between purchasing and storing. The model has been demonstrated to achieve an effective balancing of the processes of purchasing and storing auto parts, thus leading to a minimisation of general costs. It is important to note that this calculation takes into account the purchase price of different suppliers and the price for storing the auto parts during different periods.

3. Applying heuristic methods. Notwithstanding the intricacy and unfavourable complication of the task (NP-completeness), the model proposes the utilisation of heuristic methods for the identification of solutions that approximate the optimum. This has been shown to have a significant impact on the time taken to solve problems, thereby rendering it more manageable in practical situations.

Table 1
Timing belt prices of the three suppliers depending on the period

Month/Producer	Supplier 1	Supplier 2	Supplier 3
1	120	112	130
2	120	112	130
3	120	112	130
4	120	125	130
5	120	125	130
6	120	125	130
7	142	134	140
8	142	134	140
9	142	134	140
10	142	155	140
11	142	155	140
12	142	155	140

Table 2
Minimal quantities, which can be purchased by each supplier for each month

Month/Producer	Supplier 1	Supplier 2	Supplier 3
1	4	5	1
2	4	5	1
3	4	6	1
4	4	6	0
5	4	6	1
6	4	6	1
7	2	6	1
8	2	6	1
9	2	6	1
10	2	6	2
11	2	6	2
12	2	6	2

Table 3
Minimal quantities, which can be purchased by each supplier for each month

Month/Producer	Supplier 1	Supplier 2	Supplier 3
1	10	9	8
2	10	9	8
3	10	9	8
4	10	9	8
5	10	9	8
6	10	11	8
7	8	11	6
8	8	11	6
9	8	11	6
10	8	11	6
11	8	11	6
12	8	11	6

Table 4

Expected quantity to be used in repair work, minimum and maximum quantity to be stored, and cost of storing one belt for one month

Month	Quantities to be used in repair works	Minimum storage capacity	Maximum storage capacity	Storage cost per belt for one month
1	8	1	16	1.2
2	8	1	16	1.2
3	8	1	16	1.2
4	10	2	19	1.2
5	10	2	19	1.2
6	10	2	19	1.2
7	10	2	19	1.4
8	12	2	19	1.4
9	6	1	16	1.4
10	6	1	16	1.4
11	9	1	16	1.4
12	9	3	16	1.4

Table 5

Solution for the period under study

Month	Supplier 1	Supplier 2	Supplier 3	Quantity in stock
1	4	5	1	4
2	4	5	1	6
3	4	6	1	9
4	4	6	0	9
5	4	6	1	10
6	4	6	1	11
7	2	6	1	10
8	2	6	1	7
9	2	6	1	10
10	2	6	2	14
11	2	6	2	15
12	2	6	2	16

After applying the solution for model (1)-(10) as well, in Table 5 the solution for the period under study is presented.

5. Conclusions

A significant problem related to the management of stock in car services has been reviewed. The proposed optimisation model is founded on the methodologies of integer linear programming, a technique that facilitates the management of diverse facets of the problem, encompassing the selection of suppliers and/or constraints.

The application of the model in specific situations demonstrates its potential to enhance the management of stocks in a car service. Consequently, car services have the potential to reduce their general costs and enhance their productivity.

Comprehension of the intricate issue of stock management in car services provides a foundation for the formulation of pragmatic strategies to address this problem. Potential avenues for future research include the extension of the model to encompass additional factors that may influence stock management. This encompasses the temporal considerations inherent in the supply of automotive components, the evolving requirements for these components, and the potential for their return to the supplier. Furthermore, subsequent research endeavours concerning disparate management strategies should aim to undertake a comparative analysis of their efficiency under diverse conditions.

The mathematical model that has been proposed provides an efficient and practical framework for the optimisation of processes related to the procurement and storage of automotive components.

The model is founded on integer linear optimisation, incorporating heuristic methods to facilitate the generation of satisfactory solutions in a timely manner. Consequently, it pledges to enhance the efficiency and cost-effectiveness of these operations, a pivotal consideration in the contemporary business environment where enhancing resource efficiency is paramount.

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References:

Azimov, D., Stoyanova-Asenova, S., Petrova, M., & Asenov, A. (2024). Multi-Criteria Analysis Techniques to Assess the Efficiency of Using Blockchain in Logistics. *Economics Ecology Socium*, *8*, 1–11.

Galligani, E. (2006). The arithmetic mean method for solving systems of nonlinear finite difference equations. *Applied Mathematics and Computation*, 181, 579–597. DOI: https://doi.org/10.1016/j.amc.2005.12.052

Georgiev, I., Grozev, D., Pavlov, V., & Veleva, E. (2020). Comparison of heuristic algorithms for solving a specific model of transportation problem. *AIP Conference Proceedings*, 2302 (1): 060004. DOI: https://doi.org/10.1063/5.0033505

Georgiev, I., Grozev, D., Milchev, M., & Beloev, I. (2022). Optimizing the distribution of labor in car service. *AIP Conference Proceedings* 2557 (1): 080001. DOI: https://doi.org/10.1063/5.0105329

Georgiev, S., & Vulkov, L. (2021A) Fast reconstruction of time-dependent market volatility for European options. *Computational and Applied Mathematics*, 40(1):30. DOI: https://doi.org/10.1007/s40314-021-01422-9

Georgiev, S., & Vulkov, L. (2021B). Computation of the unknown volatility from integral option price observations in jump-diffusion models. *Mathematics and Computers in Simulation*, 188, 591–608. DOI: https://doi.org/10.1016/j.matcom.2021.05.008

Georgiev, S., & Todorov, V. (2023). Efficient Monte Carlo Methods for Multidimensional Modeling of Slot Machines Jackpot. *Mathematics*, *11*(2), 266. DOI: https://doi.org/10.3390/math11020266

Fapetu, O. P.; & Akinola, A. O. (2008). Optimizing auto-repair practice: Akure Metropolis as case study. *AU JT,* 11.4: 232–233.

Grozev, D., Milchev, M., Georgiev, I., & Beloev, I. (2022). Analysis of refusals when operating a car service with a non-stationary inflow of requests, *AIP Conference Proceedings* 2557 (1): 080002. DOI: https://doi.org/10.1063/5.0105950

Hassan, K. (2009). A New Quadratic Average Arithmetic Mean (QSAM) Method for Solving Diffusion Equations, *Chamchuri J. Math.*, 1, pp. 93–103.

Kholodenko, A., & Gusak, V. (2022) Initial states and transitional expenses inproduction and transport system optimization. *Access to science, business, innovation in digital economy.* ACCESS Press, 3(3): 292–306. DOI: https://doi.org/10.46656/access.2022.3.3(8)

Ma C, Hao W, He R, Jia X, Pan F, Fan J, & Xiong, R. (2018). Distribution path robust optimization of electric vehicle with multiple distribution centers. PLoS ONE 13(3): e0193789. DOI: https://doi.org/10.1371/journal.pone.0193789

Naoum-Sawaya, J., Cogill, R., Ghaddar, B., Sajja, S., Shorten, R., Taheri, N., Tommasi, P., Verago, R., & Wirth, F. (2015). Stochastic optimization approach for the car placement problem in ridesharing systems. *Transportation Research Part B: Methodological,* 80: 173–184. DOI: https://doi.org/10.1016/j.trb.2015.07.001

Nikolova-Alexieva, V., Alexieva, I., Valeva, K., & Petrova, M. (2022). Model of the Factors Affecting the Eco-Innovation Activity of Bulgarian Industrial Enterprises. *Risks, 10(9),* 178. DOI: https://doi.org/10.3390/risks10090178

Nykyforov, A., Sushchenko, O., Petrova, M. & Nataliia Pohuda. (2020). Multi-Criteria Technologies for Managerial Decisions System Analysis. *Access to science, business, innovation in digital economy.* ACCESS Press, 2(2): 150–161. DOI: https://doi.org/10.46656/access.2020.2.2(3)

Nurprihatin, F., Regina, T., & Rembulan, G.D. (2021). Optimizing rice distribution routes in Indonesia using a two-step linear programming considering logistics costs. *Journal of Physics: Conference Series,* 1811, 012010. DOI: https://doi.org/10.1088/1742-6596/1811/1/012010

Raeva, E., Pavlov, V., & Georgieva, S. (2021). Claim Reserving Estimation by Using the Chain Ladder Method. *AIP Conf. Proc.* 24 February 2021; 2321 (1): 030029. DOI: https://doi.org/10.1063/5.0040192

Raeva, E., & Pavlov, V. (2017). Planning Outstanding Reserves in General Insurance. *AIP Conf. Proc.* 12 October 2017; 1895 (1): 050009. DOI: https://doi.org/10.1063/1.5007381

Raeva E., Mihova, V., & Nikolaev, I. (2019). Using SPSS for Solving Engineering Problems. *2019 29th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE)*, 1-6.

Rashed, MT. (2003). An extension method for handling integral equations. *Applied Mathematics and Computation,* Vol. 135, No. 2-3, pp. 73–79. DOI: https://doi.org/10.1016/S0096-3003(02)00347-8

Shen, Zuo-Jun M., Feng, B., Mao, C., & Ran, L. (2019). Optimization models for electric vehicle service operations: A literature review. *Transportation Research Part B: Methodological,* 128: 462–477. DOI: https://doi.org/10.1016/j.trb.2019.08.006

Shopova, M., Petrova, M., & Todorov, L. (2023). *Trade in Recyclable Raw Materials in EU: Structural Dynamics Study*. In: Koval, V., Kazancoglu, Y., Lakatos, ES. (eds) Circular Business Management in Sustainability. ISCMEE 2022. Lecture Notes in Management and Industrial Engineering. Springer, Cham. DOI: https://doi.org/10.1007/978-3-031-23463-7_3

Sundstrom, O., & Binding, C. (2011). Flexible charging optimization for electric vehicles considering distribution grid constraints. IEEE Transactions on Smart grid, 2011, 3.1: 26–37. DOI: https://doi.org/10.1109/TSG.2011.2168431

Tairov, I., Stefanova, N., Aleksandrova, A., & Aleksandrov, M. (2024). Review of AI-Driven Solutions in Business Value and Operational Efficiency. *Economics Ecology Socium, 8,* 55–66. DOI: https://doi.org/10.61954/2616-7107/2024.8.3-5

Tzeng, G-H, & Huang, J-J. (2011). Multi-attribute decision making. Methods and applications. Boca Raton, FL, USA: CRC Press. 350 p. DOI: https://doi.org/10.1201/b11032

Wilson, D. (2015). Strategic Decision Making. In Wiley Encyclopedia of Management – Volume 12 Strategic Management (eds C.L. Cooper, J. McGee and T. Sammut-Bonnici). DOI: https://doi.org/10.1002/9781118785317.weom120115

Wilding, R., & Juriado, R. (2004). Customer perceptions of logistics outsourcing in the European consumer goods industry. *International Journal of Physical Distribution and Logistics Management*, 34 (8), 628–644. DOI: https://doi.org/10.1108/09600030410557767

Zhu, J. (2014). Quantitative models for performance evaluation and benchmarking. Data Wrapping Analysis with Spreadsheets, 3 ed. United States: Springer, page 420. DOI: https://doi.org/10.1007/978-0-387-85982-8

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