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Strategic implications of artificial intelligence on the optimisation of logistics systems

SUMMARY

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INTRODUCTION

Artificial Intelligence (AI) will revolutionize society and increase general well-being. From a logistics perspective, AI will optimise all operations needed to get goods from the manufacturer to the end customer. It will have implications for both the transportation and warehousing of goods. In the future, goods will be transported by autonomous vehicles guided by AI. The handling of goods in logistics platforms will be carried out by autonomous logistics equipment also guided by AI. Automation of processes will mean that organizations will require fewer and fewer human resources. People will have more time to innovate and engage in research and development. SMEs, being more dynamic than large companies, have the potential to benefit more from the advantages of AI. Some of the strategic implications of AI on the optimisation of logistics systems will be presented, with significant impact on global economic and social development.

The aim of the thesis is to produce a reference work in the field of logistics management that will help company managers in making decisions with strategic impact. The ideas presented are based on personal experience in the field of logistics and the implications that AI will have for economic and social development.

The research objectives are as follows:

- optimising the loading of goods onto lorry trailers, taking into account their maximum permissible weight;
- reducing logistics costs with cross-dock (CD) services;
- effective evaluation of suppliers offers in order to make the best purchases;
- developing a digitized procurement model to simplify communication with potential suppliers;
- analysis of the effects of the PNRR from the perspective of PhD students in engineering and management at Transilvania University of Brasov;
- evaluation of purchasing and sales management in CoPeL from the perspective of employees of the two departments;
- analysis of the implications of the innovative ESG-AI-BSC model on logistics management;
- determining the market value of CoPeL with a view to its sale;
- carrying out the CoPeL diagnostic analysis;
- elaboration of CoPeL development strategies;
- highlighting the superior financial results of the two newly created entities following the split of CoPeL.

The PhD thesis is structured in seven chapters. It will review scientific papers that reflect the state of the art of the strategic implications of AI on the optimisation of logistics systems (chapter 1). From a logistics management perspective (chapter 2), the transport and warehousing components will be addressed. From the transport perspective, aspects related to the transport of goods by trucks will be presented, as they have the largest share in the Romanian market. From the warehousing perspective, CD services will be described through three models, which will help to better understand the importance of this sector. From a procurement management perspective (chapter 3) the supplier selection process and the digitization of procurement will be analysed. To analyse the supplier selection process in a procurement department, four procurement models of components defining the smooth running of an enterprise will be exemplified. Digitization is the key to an organization's future development. The implications of digitization in the procurement sphere will be exemplified by a model that will describe all the steps of this process, from the sending of requests for quotation to potential suppliers to the sending of the purchase order to the selected supplier. The implications of multi-criteria analysis, brainstorming and the innovative ESG-AI-BSC model on the optimisation of logistics systems will be highlighted (chapter 4). To this end, the strategies for accessing PNRR funding will be analysed, procurement and sales management in a logistics equipment company will be analysed and the effects of the innovative ESG-AI-BSC model on the performance of logistics systems will be measured. An evaluation and diagnostic analysis of the



analysed company will be carried out (chapter 5). An assessment will be carried out using equity methods for the purpose of selling the company. Market, resources and management components will be considered for the diagnostic analysis. Finally, the development strategies of the analysed logistics equipment company will be elaborated (chapter 6). A risk management plan, a sales plan, a logistics plan and an investment plan will be developed. The research will be concluded with final conclusions, original contributions, dissemination of results and future research directions (chapter 7).

In Romania, freight transport is mainly done by lorry, by road. This requires exemplary organization of transport routes and compliance with applicable legislation. Warehouses are the core of logistics chains. Their efficiency leads to cost savings for the end customer. A special category of warehouses are CDs. They are more concerned with optimising transport routes than actual storage. The transport of different consignments of goods in different regions can be optimised by reorganizing deliveries along the route using CDs. AI will improve the process of planning transport routes and organizing warehouses.

Making the best purchases is achieved by identifying the best suppliers for the various components needed to run the organization's business. Suppliers offers should be carefully evaluated to ensure the long-term profitability of the organization. Quality and long-term vision must prevail against low prices and short-term vision. Digitization of the entire procurement process is designed to make it run more efficiently. Access to information between the organization and suppliers will be faster and transparency of decision making will be reflected in better financial results. AI will improve the process of identifying suppliers, evaluating their offers and sending orders to them.

The 15 components of the PNRR will be aimed at developing Romania's economy between 2021 and 2026. These components will be analysed by PhD students from the engineering and management specialization at Transilvania University of Brasov. Brainstorming and multi-criteria analysis of the ideas will be carried out. Finally, relevant conclusions will be drawn on the effects of the PNRR components on the future evolution of the Romanian economy. CoPeL's purchasing and sales management will be analysed from the perspective of the employees of the two departments of this company. A brainstorming and a multi-criteria analysis of the ideas will be carried out. Finally, aspects with the potential to generate added value for the organization will be highlighted. Procurement and sales strategies may improve and CoPeL's financial results may exceed initial expectations. The implications of the innovative ESG-AI-BSC model on logistics management will be analysed. Environmental, social and corporate governance issues have a particular impact in the transport and logistics platforms sphere. AI will revolutionize socio-economic development, also impacting on the logistics sector. The performance of the education system must increase in the areas of transport and warehousing, the internal procedures of logistics companies must take sustainability into account, adaptation to customer needs must respect quality principles and the financial component must be oriented towards generating added value.

The value of a company is determined through an assessment process carried out by independent chartered evaluators. The assessment can be done in different ways, but in practice equity methods are preferred to establish the market value of a company. For CoPeL the market value will be established for the purpose of its sale. A diagnostic analysis of CoPeL will also be carried out. This diagnostic analysis will consist of market, resources and management components. The resource component will have a higher weighting. The company will be given a score when the diagnostic analysis is carried out. The result obtained will form the basis for further development strategies. AI will facilitate the diagnostic assessment and analysis process by gathering information more quickly and providing simplified preliminary models more quickly.

To develop CoPeL's development strategies, strategies to reduce the impact of risks, strategies to make sales more efficient, strategies to optimise logistics and strategies to maximize the effect of investments will be highlighted. To maintain the SME status, the strategy of splitting up the company will be implemented as soon as the turnover approaches the legal limit for this status. It will be noted that following the splitting of the firm, the financial results of the two newly created companies will be better than if the firm was not split. The AI will take over most of the tasks of the managers in the future and will

quickly recommend sustainable strategies for the development of the organization. The role of managers will be to adapt these strategies to the company they represent.

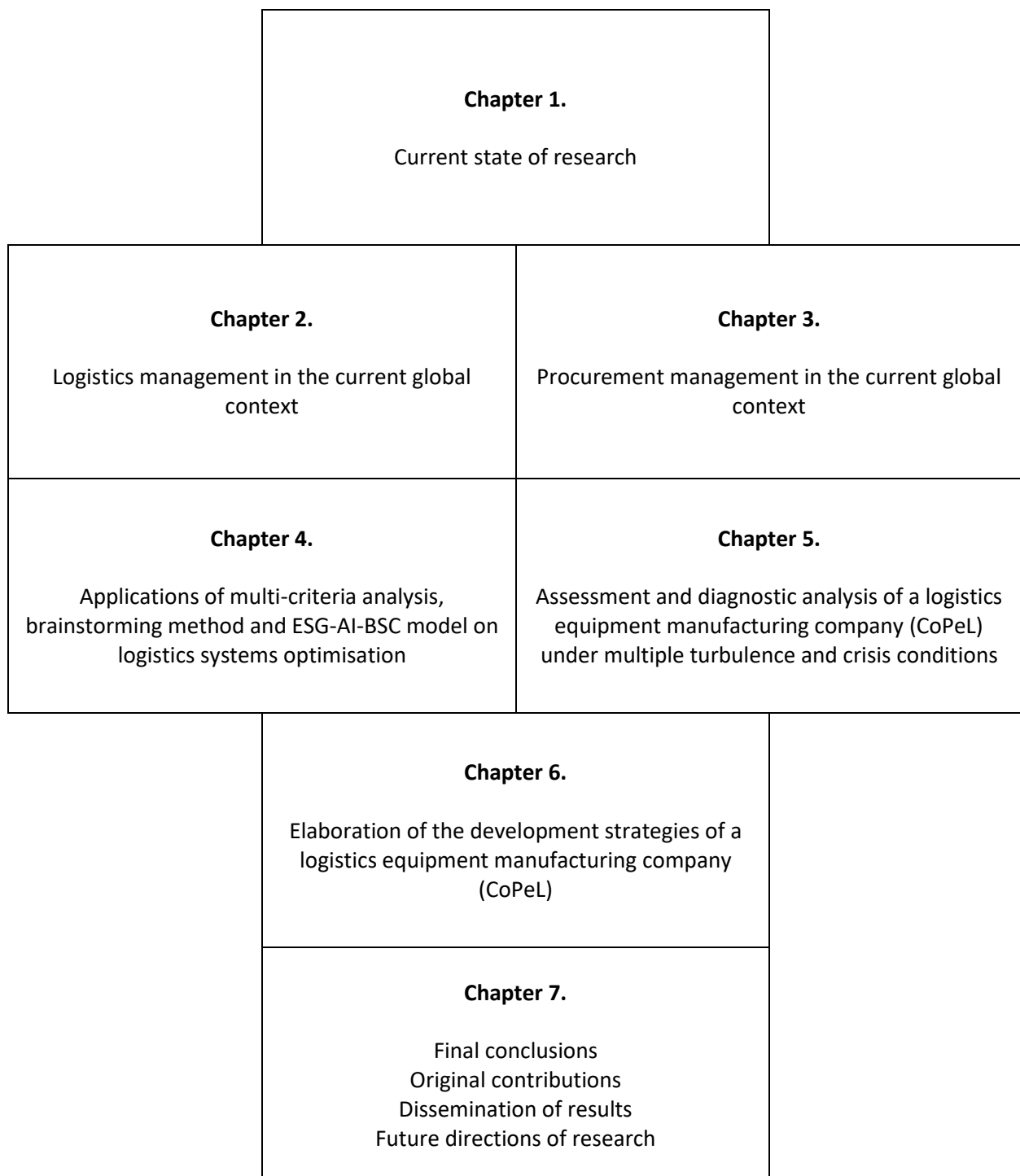


Figure 1. Structure of the PhD thesis

The research methodology is based on the analysis of 205 bibliographical references. The legislative implications of loading goods onto trucks by weight will be analysed. CD services will be analysed from the perspective of the added value they can generate throughout the logistics chain. A supplier selection process will be carried out for four categories of components necessary for the smooth running of the business. A simplified model for digitizing procurement will be developed to optimise internal



procurement processes. A multi-criteria analysis of brainstorming ideas will be carried out in PNRR and in CoPeL's procurement and sales management. The implications of the ESG-AI-BSC model in the logistics sphere will be analysed. The ESG-AI model will be analysed in terms of learning, internal processes, customers and financial criteria and the ESG-AI-BSC matrix will be produced. To facilitate the assessment and diagnostic analysis process of CoPeL a micro-environment, SWOT, turnover, profit, product portfolio and sales analysis will be carried out. An assessment of CoPeL will be carried out using the equity methods of net book assets and adjusted net assets, for the purpose of sale. A diagnostic analysis of CoPeL will be carried out to determine the level of performance of the company under review. To achieve this, a strategic diagnosis of the market, resources and management will be drawn up.

PEST analysis, Ansoff matrix, Boston Consulting Group, Porter analysis, a comparison of CO₂ emissions between diesel-powered forklift trucks and electric forklift trucks, calculation of some financial indicators, summary of the organization's mission statement, analysis of key success factors, strategic business areas and CoPeL's organizational structure will be carried out. Development strategies of the analysed company will be elaborated. A risk management plan will be developed following the qualitative and quantitative risk analysis. A sales plan until 2027 will be developed in terms of number of employees and sales budget. A logistics plan will be developed through the activity-based costing, activity-based management, benchmarking method and the McKinsey 7S model.

An investment plan will be drawn up, recommending some modern investment financing opportunities, projecting the profit and loss account until 2027 and evaluating the investment in terms of financial indicators. To achieve superior financial results, the strategy of splitting the company will be implemented to maintain the SME status of both newly created entities. Two companies will be created, one specializing in the production of new logistics equipment and the other specializing in the refurbishment of used logistics equipment. The stages and characteristics of the electric forklift trucks refurbishment process will be outlined. The conclusions of the research will aim to highlight the added value generated by the strategic implications of AI on socio-economic development in general and on the optimisation of logistics systems in particular.

For the realization of this PhD thesis, I thank my scientific supervisor prof. dr. eng. ec. Boşcoianu Mircea. His recommendations and ideas contributed substantially to the success of this scientific work. I thank the members of the steering committee for their support: prof. dr. eng. Calefariu Gavrilă, prof. dr. eng. Repanovici Angela, conf. dr. eng. Sârbu Flavius-Aurelian and dr. ec. Vătăşitoru Eugen-Silviu. Finally, I thank all the teaching staff of the Department of Engineering and Industrial Management of Transilvania University of Brasov.

CHAPTER 1. CURRENT STATE OF RESEARCH

Keywords	Year of publication	Authors	Article title	Research contributions
Artificial Intelligence	2022	Feuerriegel S., Shrestha Y. R., von Krogh G., Zhang C.	“Bringing artificial intelligence to business management”	Implementing AI in management is delegating decision-making to AI. In practice, interdisciplinary research using AI will be used to achieve management objectives.
	2022	Hasija A., Esper T. L.	“In artificial intelligence (AI) we trust: a qualitative investigation of AI technology acceptance”	The impact of AI on supply chain management is growing. The advantages and disadvantages of implementing AI in this sector are weighed. The social implications demonstrate that AI is feasible and worth pursuing.
	2022	Krakowski S., Luger J., Raisch S.	“Artificial intelligence and the changing sources of competitive advantage”	In a dynamic market AI can be substitutable or complementary to ensure competitive advantage. Now people matter a lot, and the traditional approach is the majority although AI is gaining ground.
Logistics optimisation	2022	Chen N., Wen Y.	“Research on application of forklift dispatching intelligence in industrial intelligence”	Forklift technology development will streamline industrial production, transport and warehousing logistics. This development is closely linked to the development and implementation of AI to ensure automation of the entire logistics chain.
	2022	Klumpp M., Ruiner C.	“Artificial intelligence, robotics, and logistics employment: the human factor in digital logistics”	Human resources are important in logistics, although digitization is gaining ground. Human resources are also a major player in logistics-related areas such as intralogistics, supply chains and modern AI-driven technologies.
	2023	Yurt O., Sorkun M. F., Hsuan J.	“Modularization of the front-end logistics services in e-fulfillment”	Heterogeneous customer needs are costly. Logistics services tailored to customers consider their profiles, performance and variety. Customer preferences underpin the interdependence of service elements and processes for modularization.
Supply chains	2023	Hendriksen C.	“Artificial intelligence for supply chain management: disruptive innovation or innovative disruption?”	The implications of AI on supply chains will be multidisciplinary. In some respects, supply chain management cannot match the level of complexity of AI, which can implement innovative solutions.

	2023	Hofer C., D'Oria L., Cantor D. E., Ren X.	“Competitive actions and supply chain relationships: how suppliers' value-diminishing actions affect buyers' procurement decisions”	In a competitive market, supplier's actions are intended to change the market trend. A decrease in the quality of products and services offered will be accompanied by a decrease in demand for the supplier. The fall in the price offered compensates for the fall in demand from customers in the short term.
	2023	Richey Jr. R. G., Chowdhury S., Davis-Sramek B., Giannakis M., Dwivedi Y. K.	“Artificial intelligence in logistics and supply chain management: a primer and roadmap for research”	AI will have diverse implications for logistics and supply chain management. The benefits will be in making these two areas more efficient with implications for socio-economic development. AI modules are in a continuous progressive dynamic.
Strategic management	2022	De-Arteaga M., Feuerriegel S., Saar-Tsechansky M.	“Algorithmic fairness in business analytics: directions for research and practice”	Business analysis helps companies gain competitive advantages over the competition. Decisions are made not only with a view to profit but also to the well-being of all stakeholders. It ensures objectivity by eliminating human interference.
	2023	Dencker J. C., Gruber M., Miller T., Rouse E. D., von Krogh G.	“Positioning research on novel phenomena: the winding road from periphery to core”	Today, constant change provides researchers with new research opportunities. New ideas travel from the periphery of the field to its core. Research into new phenomena enhances subsequent rapid technological development.
	2023	Wang W., Dinh J. V., Jones K. S., Upadhyay S., Yang J.	“Corporate diversity statements and employees' online DEI ratings: an unsupervised machine-learning text-mining analysis”	Diversity of human resources is the challenge for companies in developing development strategies. Equity of access to information depends on the availability of modern technologies. Social inclusion of disadvantaged groups involves the development of the education system.
Sustainable development	2022	Chowdhury S., Budhwar P., Dey P. K., Joel-Edgar S., Abadie A.	“AI-employee collaboration and business performance: Integrating knowledge-based view, socio-technical systems and organisational socialisation framework”	The interplay between AI and the human factor will be critical to business performance. Knowledge-based vision underpins the development of effective strategies. Socio-technical systems ensure the implementation of the technological revolution worldwide. Effective organizational socialization ensures the optimisation of information flow to increase business competitiveness.



	2023	Fatimah Y. A., Kannan D., Govindan K., Hasibuan Z. A.	“Circular economy e-business model portfolio development for e-business applications: impacts on ESG and sustainability performance”	Digitizing the circular economy can be the innovative solution to solving organizations problems intelligently. The e-business model is proving to be very well suited to addressing environmental issues, solving a good part of social problems and providing solutions to improve corporate governance policies.
	2022	Makaryan S., Hoppe H., Fortuin K.	“The potential for a circular economy in the nonroad mobile machinery industry - the case of Linde Material Handling GmbH”	The circular economy encompasses resources that can be reused within a company. Competition in the market will force companies to develop the machinery refurbishment process. Large companies with a wide range of products and full customer service will benefit.

CHAPTER 2. LOGISTICS MANAGEMENT IN THE CURRENT GLOBAL CONTEXT

The objectives of this chapter are:

- O.2.1: Optimising the loading of goods onto lorry trailers, taking into account their maximum permissible weight;
- O.2.2: Reducing logistics costs with cross-dock (CD) services.

In order not to exceed the maximum permissible axle weight of a lorry with trailer (mega or euro) on public roads, the loaded cargo must not exceed:

- 4,5 tons of goods per first quarter of the trailer;
- 11 tons of goods on the first half of the trailer;
- 24 tons of goods distributed over the whole trailer.

Table 1. Weight distribution of goods on a trailer (Euro pallets with overlap factor 2)

Average pallet weight with goods	Weight on the first quarter of the trailer	Weight on the first half of the trailer	Total weight of goods in the trailer
Maximum 260 kg	4,42 tons	8,84 tons	17,16 tons
Approximately 300 kg	3,90 tons	9,00 tons	18,60 tons
Approximately 400 kg	3,60 tons	10,40 tons	23,20 tons
Approximately 500 kg	4,25 tons	8,50 tons	24,00 tons

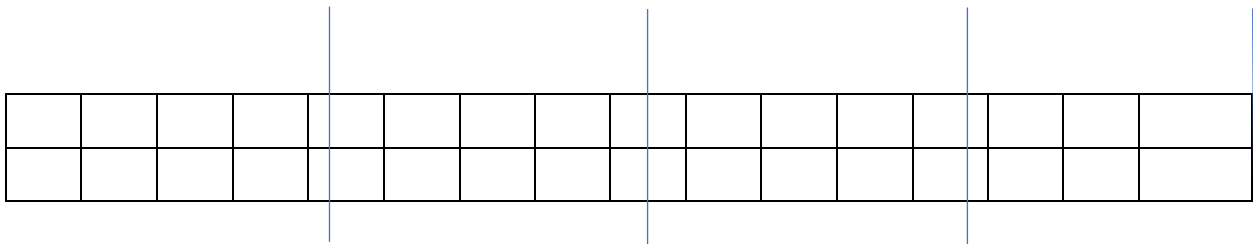


Figure 2. Placing euro pallets with a maximum weight of 260 kg on the trailer (side view)

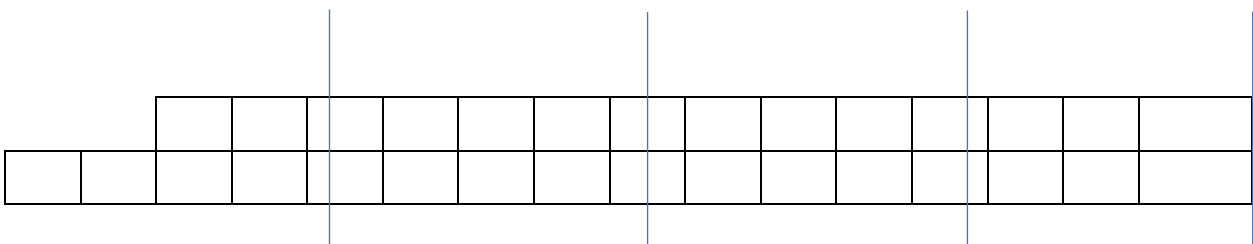


Figure 3. Placing euro pallets with average weight of 300 kg on the trailer (side view)

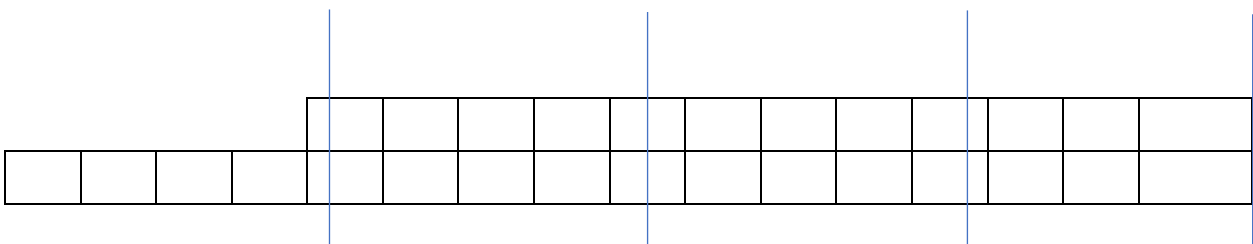


Figure 4. Placing euro pallets with average weight of 400 kg on the trailer (side view)

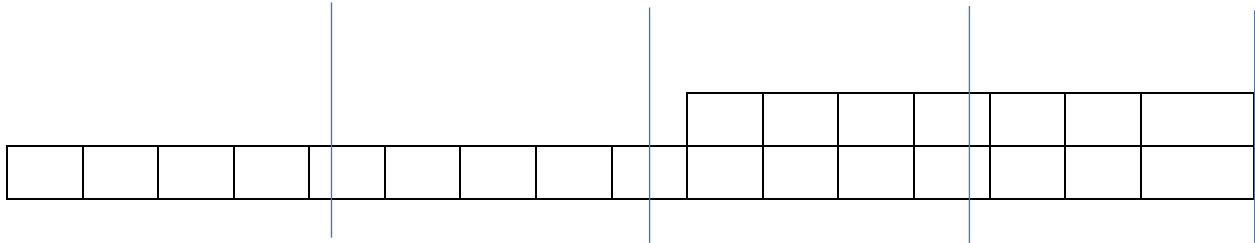


Figure 5. Placing euro pallets with average weight of 500 kg on the trailer (side view)

The case of four trucks loaded with goods from Romania, Bulgaria, Hungary and Slovakia will be analysed. On each of these trucks, a quarter of the loaded cargo is to be delivered to Germany, the Netherlands, France and Spain. Normally these trucks would have to travel to each of these countries to unload the loaded goods. In the proposed simplified CD service model, the trucks will carry the initially loaded goods only to the CD in Poland. In this CD all these goods will be unloaded and separated by destinations. All German freight will be loaded on only one of these trucks, which will continue to deliver only German freight. The same applies to goods for the Netherlands, France and Spain. A calculation of the economic efficiency of transport costs will be made for each delivery of goods related to each loaded truck, at an estimated cost of 1.40 euros / km.

Table 2. Reduction of logistics expenses with the help of CD services (simplified model)

Logistics expenses	Cost
Total expenses without CD services	20.847 euros
Total expenses with CD services	16.093 euros
Saving logistics costs	4.754 euros
The percentage of reduction in logistics expenses	22,80%

In the following, five trucks loading euro pallets with goods from six different cities in Romania will be analysed. The goods will be delivered to eight cities in Western Europe. A CD located in Arad will be chosen.

Table 3. Availability of goods in the six cities in Romania

Loading \ Unloading	Bucharest	Pitesti	Cluj-Napoca	Timisoara	Sibiu	Brasov
London	5,20 t 4,80 lm	4,60 t 3,20 lm				
Hamburg					3,20 t 4,00 lm	(5) 7,60 t 7,20 lm
Berlin			1,80 t 2,40 lm		4,40 t 4,00 lm	(5) 7,80 t 5,60 lm
Paris			10,50 t 9,60 lm	2,60 t 3,20 lm		
Madrid				6,20 t 5,60 lm		
Amsterdam						(4) 3,60 t 3,20 lm
Brussels						(4) 2,40 t

						1,60 lm
Milan	1,40 t 2,40 lm			3,90 t 4,00 lm		
Total	6,60 t 7,20 lm	4,60 t 3,20 lm	12,30 t 12,00 lm	12,70 t 12,80 lm	7,60 t 8,00 lm	21,40 t 17,60 lm

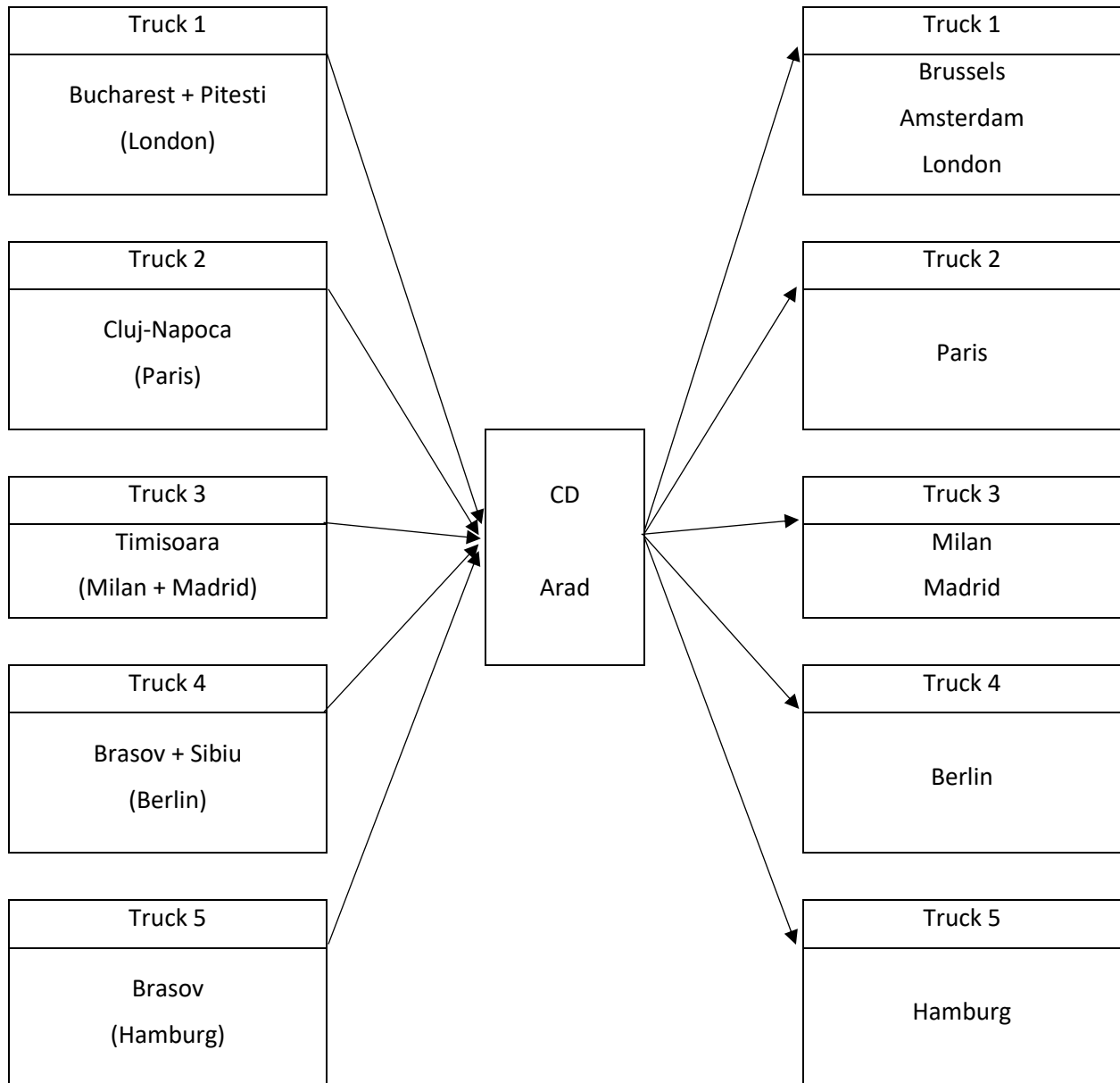


Figure 6. Complex (optimised) CD service model

Table 4. Reduction of logistics expenses with the help of CD services (complex model)

Logistics expenses	Cost
Total expenses without CD services	18.488 euros
Total expenses with CD services	16.509 euros
Saving logistics costs	1.979 euros
The percentage of reduction in logistics expenses	10,70%

To optimise logistics expenses, the trucks will no longer unload all the goods at the CD in Arad. Subsequent deliveries will be planned to consider some cargo lots that are already loaded on them. It will be desired that at least one batch of loaded cargo does not incur additional handling charges.

Table 5. Reduction of logistics expenses with the help of CD services (optimised model)

Logistics expenses	Cost
Total expenses without CD services	18.488 euros
Total expenses with CD services	15.933 euros
Saving logistics costs	2.555 euros
The percentage of reduction in logistics expenses	13,82%

The main conclusions of this chapter are:

- C.2.1: Four scenarios were presented to optimise the loading of goods on truck trailers, considering their maximum weight. These have the final result of reducing the total transport costs;
- C.2.2: Three CD service models were presented that generated profits of more than 10% compared to the classic freight delivery model. It can be concluded that CD services help to optimise logistics expenses. Large investments are needed to create as many such logistics platforms as possible. AI will help optimise logistics processes through better organization of CDs, inventory records and planning of transport routes. By increasing the market share of logistics services, the degree of experience of the people involved in this field will also increase. This can reduce potential claims expenses, but the rate of profit will also decrease due to increased competition. AI will solve the problem of insufficient skilled human resources in the logistics sector by implementing autonomous logistics equipment and autonomous vehicles.

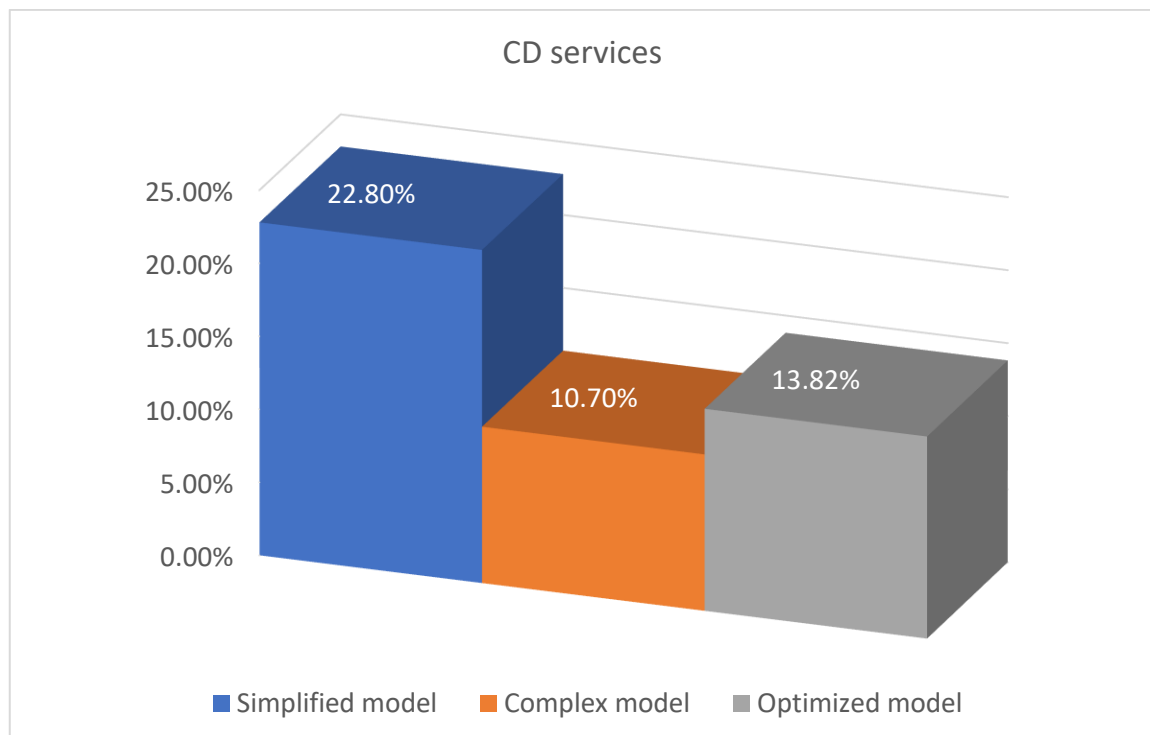


Figure 7. The percentage reduction of logistics expenses by using CD services

CHAPTER 3. PROCUREMENT MANAGEMENT IN THE CURRENT GLOBAL CONTEXT

The objectives of this chapter are:

- O.3.1: Effective evaluation of suppliers offers in order to make the best purchases;
- O.3.2: Developing a digitized procurement model to simplify communication with potential suppliers.

Some cases of supplier selection will be analysed below.

Table 6. Analysis of metal construction suppliers offers

Supplier	Price	Payment term	Advance payment	Delivery time	Transport
Supplier 1	24.250 euros	30 days	50%	30 days	Included
Supplier 2	25.680 euros	30 days	25%	45 days	200 euros
Supplier 3	25.200 euros	60 days	50%	60 days	Included
Supplier 4	28.490 euros	30 days	Without	45 days	Included
Supplier 5	26.500 euros	45 days	Without	30 days	250 euros

Table 7. Values given to metal construction suppliers

Supplier	Price (50%)	Payment term (15%)	Advance payment (15%)	Delivery time (10%)	Transport (10%)	Weighted average of the values	Ranking
Supplier 1	1	4	4,5	1,5	2	2,125	1 st place
Supplier 2	3	4	3	3,5	4	3,300	4 th place
Supplier 3	2	1	4,5	5	2	2,525	2 nd place
Supplier 4	5	4	1,5	3,5	2	3,875	5 th place
Supplier 5	4	2	1,5	1,5	5	3,175	3 rd place

Table 8. Analysis of hand tool suppliers offers

Supplier	Price	Payment term	Advance payment	Delivery time	Transport
Supplier 1	859 euros	60 days	Without	120 days	Included
Supplier 2	816 euros	15 days	25%	45 days	180 euro
Supplier 3	849 euros	On delivery	Without	60 days	Included
Supplier 4	860 euros	30 days	50%	30 days	Included
Supplier 5	813 euros	30 days	Without	90 days	220 euro

Table 9. Values given to hand tool suppliers

Supplier	Price (50%)	Payment term (15%)	Advance payment (15%)	Delivery time (10%)	Transport (10%)	Weighted average of the values	Ranking
Supplier 1	4	1	2	5	2	3,150	4 th place
Supplier 2	2	4	4	2	4	2,800	2 nd place
Supplier 3	3	5	2	3	2	3,050	3 rd place
Supplier 4	5	2,5	5	1	2	3,925	5 th place
Supplier 5	1	2,5	2	4	5	2,075	1 st place

In the digitization process, different IT programs are used for planning the organization's resources. In the digitized procurement process, several stages are covered, with the aim of obtaining the best offers from potential suppliers more easily.

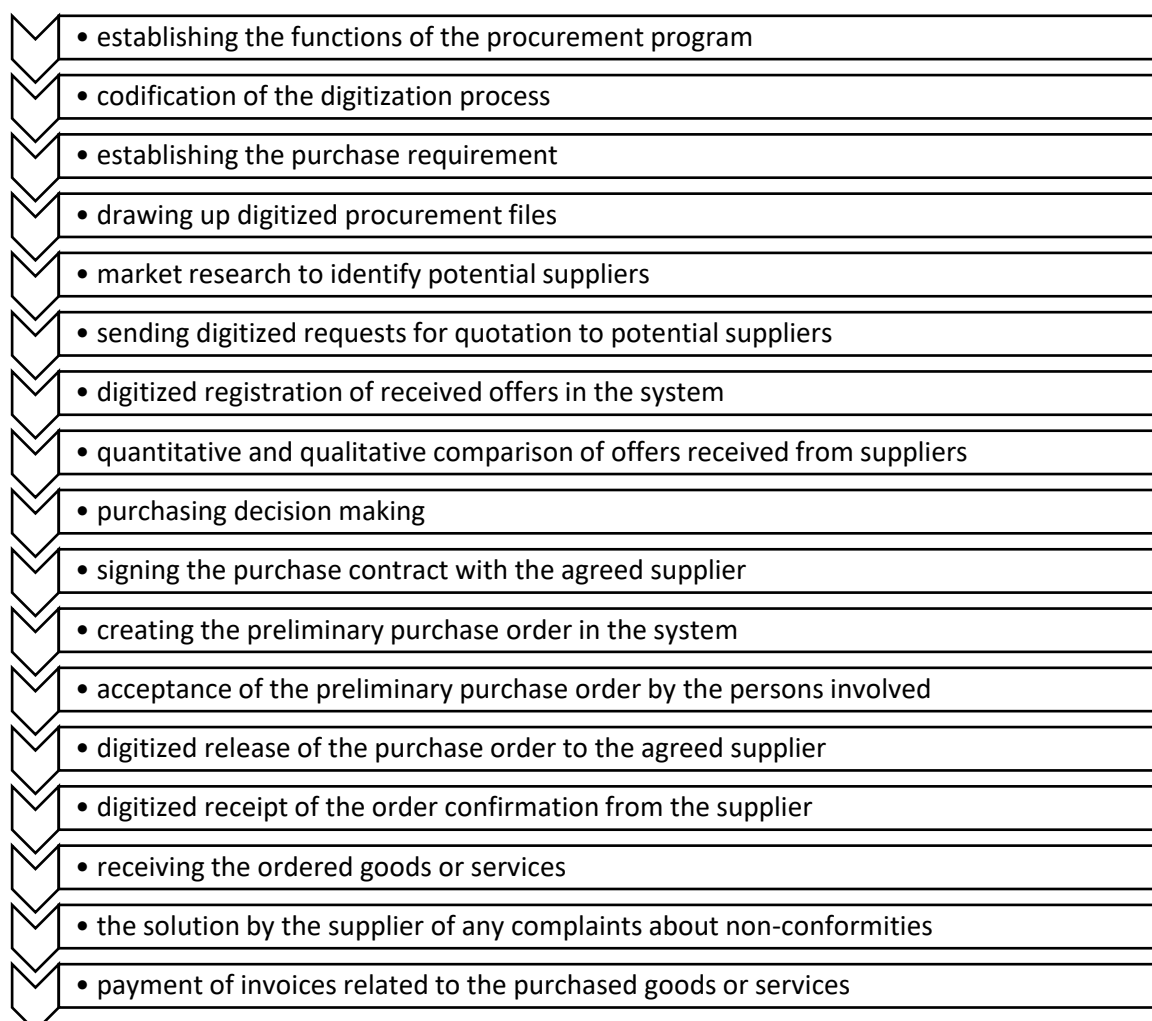



Figure 8. Stages of the procurement digitization process

Table 10. Creation of a digitized request for quotation

Function	CEROFE	Status	Finished	Operator	TOZS01
Save	Send email	Print	Back	Forward	Close
Purchasing centre			100100		
Procurement file number			200200		
Purchase file date			20.01.2023		
Deadline for receiving offers			10.03.2023		
Current number	Product code	Product description	Required quantity	Measure unit	Delivery date
1	600001	Drill 2 mm	10	Pcs.	15.04.23
2	600002	Drill 2,5 mm	10	Pcs.	15.04.23
3	600003	Drill 3 mm	10	Pcs.	15.04.23
4	600004	Fuse 10	50	Pcs.	15.04.23

5	600005	Fuse 20	50	Pcs.	15.04.23
6	600006	Fuse 30	50	Pcs.	15.04.23
7	600007	Abr. disc 125x22	20	Pcs.	15.04.23
8	600008	Protective gloves	100	Pcs.	15.04.23

Table 11. Purchase order

Function	COMACH	Status	Finished	Operator	TOZS01		
Save	Send email	Print	Back	Forward	Close		
Accept	SA		MA	DC			
Order number	500501						
Date of order	14.03.2023						
Supplier code	300300						
Supplier name	SC Industriaşul SRL						
Street	Sânzienelor	Number	20				
City	Bucharest	Postal code	010051				
Purchasing centre	100100						
Delivery address	CoPeL	Ploiesti, Industriei str., no. 85, 500046					
Payment deadline	30 days						
Terms of delivery	DAP Brasov						
Currency	Euro						
Comments	According to the offer 4589 Please send order confirmation						
Current number	Product code	Product description	Required quantity	Measure unit	Unit price	Total price	Delivery date
1	600001	Drill 2 mm	10	Pcs.	0,62	6,20	30.03.23
2	600002	Drill 2,5 mm	10	Pcs.	0,66	6,60	30.03.23
3	600003	Drill 3 mm	10	Pcs.	0,69	6,90	30.03.23
4	600004	Fuse 10	50	Pcs.	0,11	5,50	30.03.23
5	600005	Fuse 20	50	Pcs.	0,12	6,00	30.03.23
6	600006	Fuse 30	50	Pcs.	0,13	6,50	30.03.23
7	600007	Abr. disc 125x22	20	Pcs.	1,31	26,20	30.03.23
8	600008	Protective gloves	100	Pcs.	0,16	16,00	30.03.23
Total amount	79,90 euros						
Logistics costs	50,00 euros						
Total order value	129,90 euros						
Discount	5%						
Total order value with discount	123,41 euros						

The main conclusions of this chapter are:

- C.3.1: Four cases of evaluating the offers of some suppliers were presented. Following this process, the best offers necessary for the smooth running of the procurement process were identified. AI will enable faster evaluation and identification of these offers. The human factor will be needed only in the case of super-specialized products;
- C.3.2: A simplified model of procurement digitization was presented. It aims to improve the flow of information, emphasizing the quality side of the procurement process. AI will optimise the entire process of digitizing procurement.

CHAPTER 4. APPLICATIONS OF MULTI-CRITERIA ANALYSIS, BRAINSTORMING METHOD AND ESG-AI-BSC MODEL ON LOGISTICS SYSTEMS OPTIMISATION

The objectives of this chapter are:

- O.4.1: Analysis of the effects of the PNRR from the perspective of PhD students in engineering and management at Transilvania University of Brasov;
- O.4.2: Evaluation of purchasing and sales management in CoPeL from the perspective of employees of the two departments;
- O.4.3: Analysis of the implications of the innovative ESG-AI-BSC model on logistics management.

To highlight the components of the strategies for accessing PNRR funding, a brainstorming session was organized in February 2024 with five PhD colleagues in engineering and management from Transilvania University of Brasov. 60 ideas were grouped into eight categories to develop relevant and pertinent working variants on strategies for accessing PNRR funding.

A multi-criteria analysis was carried out in which the eight work variants were analysed according to five analysis criteria established after consultation with five specialists in the field of implementation of European funds. The five analysis criteria were compared with each other two by two using the Analytical Hierarchy Process method. Scores from 1 to 5 were given for the analysis of each work variant according to each established analysis criterion. The weights of the criteria were multiplied by the scores given to the working variants.

Table 12. Determining the winning working variant of strategies for accessing PNRR funding

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Total	Ranking
Variant 1	1,95	1,08	0,18	0,72	0,30	4,23	2 nd place
Variant 2	1,95	1,35	0,18	0,54	0,40	4,42	1 st place
Variant 3	1,17	0,81	0,24	0,54	0,30	3,06	7 th place
Variant 4	1,56	1,08	0,12	0,72	0,40	3,88	3 rd place
Variant 5	1,17	1,35	0,24	0,36	0,30	3,42	5 th place
Variant 6	1,17	1,08	0,12	0,36	0,20	2,93	8 th place
Variant 7	1,17	0,81	0,12	0,72	0,40	3,22	6 th place
Variant 8	1,56	1,08	0,18	0,72	0,30	3,84	4 th place

CoPeL is based in Ploiesti, jud. Prahova. Its main activity is the production and marketing of state-of-the-art logistics equipment. Two brainstorming sessions were conducted in March 2024, one with five representatives of the purchasing department and one with five representatives of the sales department of CoPeL. 50 ideas were generated for each brainstorming session, resulting in six working variants.

A multi-criteria analysis was conducted in which the six work variants were analysed according to five analysis criteria designated by the company management. The five analysis criteria were compared with each other two by two using the Analytical Hierarchy Process method. Scores from 1 to 5 were given for the analysis of each work variant according to each analysis criterion set. The weights of the criteria were multiplied by the scores given to the work variants.

Table 13. Determining the winning working variant within the CoPeL procurement department

	Criterion 1A	Criterion 2A	Criterion 3A	Criterion 4A	Criterion 5A	Total	Ranking
Variant 1A	0,18	0,40	0,72	1,56	0,81	3,67	5 th place
Variant 2A	0,12	0,30	0,72	1,17	0,81	3,12	6 th place
Variant 3A	0,18	0,40	0,72	1,56	1,08	3,94	4 th place
Variant 4A	0,18	0,40	0,90	1,56	1,08	4,12	2 nd place
Variant 5A	0,18	0,50	0,72	1,56	1,08	4,04	3 rd place
Variant 6A	0,24	0,40	0,90	1,56	1,08	4,18	1 st place

Table 14. Determining the winning working variant within the CoPeL sales department

	Criterion 1V	Criterion 2V	Criterion 3V	Criterion 4V	Criterion 5V	Total	Ranking
Variant 1V	0,18	1,08	0,54	0,30	1,95	4,05	2 nd place
Variant 2V	0,18	0,81	0,72	0,40	1,56	3,67	6 th place
Variant 3V	0,24	1,08	0,54	0,50	1,56	3,92	5 th place
Variant 4V	0,18	1,08	0,72	0,40	1,56	3,94	4 th place
Variant 5V	0,18	1,08	0,72	0,50	1,56	4,04	3 rd place
Variant 6V	0,24	1,35	0,90	0,40	1,56	4,45	1 st place

The innovative ESG-AI-BSC model is intended to be one of the pillars of sustainable economic and social development. In logistics management, the ESG-AI-BSC innovative model will have the following implications:

- clean transport and energy-independent logistics platforms (E);
- increased social cohesion and sustainable jobs (S);
- government support and cost reduction (G);
- autonomous vehicles and automated warehouses (AI);
- lifelong learning adapted to market needs (L);
- streamlining internal processes to optimise supply chains (P);
- customer orientation through a better understanding of customer needs (C);
- efficient allocation of financial resources with a focus on cost reduction (F).

Table 15. Multi-criteria analysis of the ESG-AI model according to the BSC criteria

	L	P	C	F	Total	Ranking
E	1	2	1	3	7	4 th place
S	3	1	2	2	8	3 rd place
G	2	3	4	1	10	2 nd place
IA	4	4	3	4	15	1 st place

Table 16. ESG-AI-BSC matrix

	E	S	G	IA	L	P	C	F
E	1	6	7	5	2	3	1	4
S	1	1	6	4	5	3	2	7
G	2	4	3	7	1	5	3	6
IA	5	6	3	3	2	7	4	1
L	4	6	1	7	2	3	2	5



P	4	2	3	7	6	5	5	1
C	6	5	7	3	1	2	7	4
F	4	1	6	5	2	3	7	1
Total	26	30	33	38	19	26	24	28
Ranking	5,5 th place	3 rd place	2 nd place	1 st place	8 th place	5,5 th place	7 th place	4 th place

The main conclusions of this chapter are:

- C.4.1: The PNRR was designed to offset the effects of the COVID-19 pandemic. Each EU country has its own PNRR funded by loans and grants from EU joint loans at lower interest rates. PNRR loans have low EU interest rates and grants are interest-free. The EU subsidizes us to make structural reforms, while poorer countries need to be subsidized more. The PNRR has clear implementation chapters, but bureaucracy makes PNRR money hard to attract;
- C.4.2: From the perspective of CoPeL's procurement department, compliance with the planned timetables is linked to the need for continuous improvement in time management. Employee cohesion is achieved through compliance with legal requirements and continuous professional development. A scientific approach is needed to optimise the dense organization chart. From the perspective of CoPeL's sales department, lithium-ion battery electric logistics equipment is being developed. Although lithium-ion batteries cost twice as much as lead-acid batteries, lithium-ion technology is more cost-effective. The company has stopped producing diesel-powered forklift trucks and offers used equipment for rent. Equipment maintenance is provided through full maintenance contracts;
- C.4.3: The most important component of the ESG-AI-BSC model's implications for logistics management is AI. It will support the promotion and popularization of autonomous vehicles. AI will ensure the development of fully automated logistics platforms. The human workforce will have only the role of supervising and maintaining equipment. AI will prevent natural disasters, help increase social cohesion by eradicating poverty and optimise managerial decisions with artificial management.

CHAPTER 5. ASSESSMENT AND DIAGNOSTIC ANALYSIS OF A LOGISTICS EQUIPMENT MANUFACTURING COMPANY (CoPeL) UNDER MULTIPLE TURBULENCE AND CRISIS CONDITIONS

The objectives of this chapter are:

- O.5.1: Determining the market value of CoPeL with a view to its sale;
- O.5.2: Carrying out the CoPeL diagnostic analysis.

CoPeL was founded in 2015 in Ploiesti, jud. Prahova. The company's core products are electric forklift trucks and pallet trucks with lithium-ion batteries. The company follows the market trend in terms of sustainability by reducing CO₂ emissions.

To determine the market value of CoPeL, the assessment will be carried out using the equity methods, the net book asset method and the adjusted net asset method.

Net book assets = Total assets – Total liabilities

Adjusted net assets = Adjusted total assets – Adjusted total liabilities

Table 17. Values resulting from equity assessment methods

Year	Total assets	Total liabilities	Net book assets	Inflation on 31.12.2023	Indexed net book assets	
					(RON)	(EUR)
2022	226.113.289	199.959.368	26.153.921	6,61%	27.882.695	5.610.200
Year	Adjusted total assets	Adjusted total liabilities	Adjusted net assets	Inflation on 31.12.2023	Indexed adjusted net assets	
					(RON)	(EUR)
2022	230.176.207	213.956.523	16.219.684	6,61%	17.291.805	3.479.236

Table 18. Adjusted values for 2022

Name of balance sheet indicators	2022	Adjustments	Adjusted values
Fixed assets - total	149.307.079	7.465.354	156.772.433
Current assets - total, of which	76.408.870	- 3.414.356	72.994.514
- Inventories	24.939.533	- 1.246.977	23.692.556
- Receivables	46.393.241	- 2.319.662	44.073.579
- House and bank accounts	5.076.096	152.283	5.228.379
Prepaid expenses	397.340	11.920	409.260
Total assets	226.113.289	4.062.918	230.176.207
Debts	199.959.368	13.997.155	213.956.523
Provisions	1.532.265	- 76.613	1.455.652
Capital	24.621.656	- 9.857.624	14.764.032
Total liabilities	226.113.289	4.062.918	230.176.207

The object of the assessment is to establish the market value of CoPeL and the purpose of the assessment is to be used for sale. The value chosen will be the adjusted net assets equity method (17.291.805 lei / 3.479.236 euro). The exchange rate of 4,97 lei / 1 euro, valid on 31.12.2023, was used to establish the values in euro. In the assessment process the amounts are rounded, resulting in this case in final values of RON 17.000.000 / EUR 3.500.000.

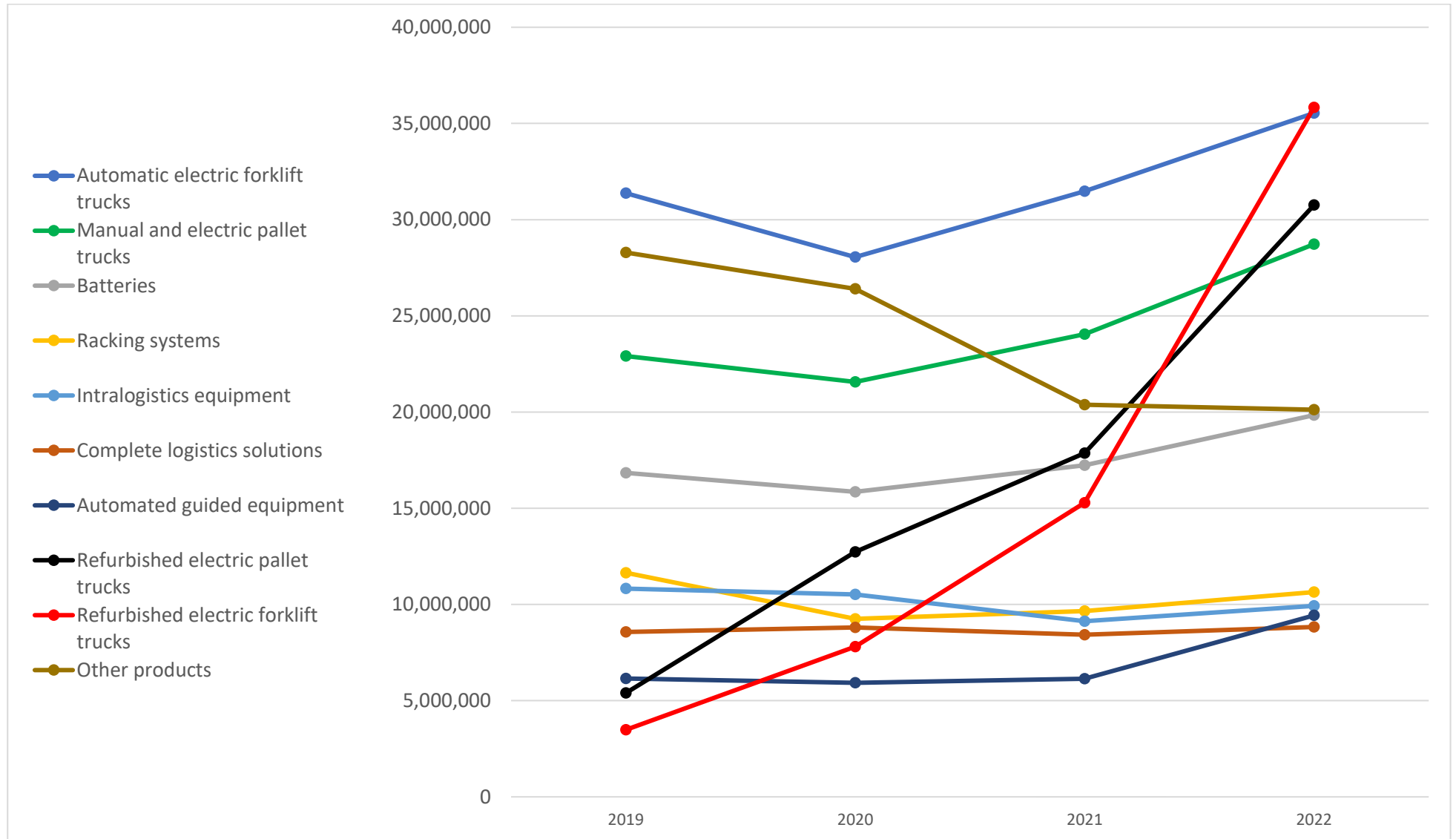


Figure 9. Evolution of CoPeL product sales between 2019 – 2022

In developing the final diagnostic analysis (DA), the strategic resource diagnosis (RD) will have a weight of 40% and the strategic market diagnosis (PD) and management diagnosis (MD) will have a weight of 30% each.

$$DA = 0,30 \times PD + 0,40 \times RD + 0,30 \times MD$$

Weights between 0 and 1 will be given for the degree of importance of each criterion of the diagnostic analysis. Values between 1 and 5 will be given for the assessment of the results of each criterion of the diagnostic analysis.

Table 19. Diagnostic analysis of the market, resources and management

Diagnostic analysis criterion	Importance	Assessment
Demand diagnosis	0,30	3
Supply diagnosis	0,30	4
Competition diagnosis	0,40	3
Strategic market diagnosis	$PD = 0,30 \times 3 + 0,30 \times 4 + 0,40 \times 3 = 3,30$	
Technical resources diagnosis	0,35	4
Human resources diagnosis	0,25	4
Financial resources diagnosis	0,40	3
Strategic resource diagnosis	$RD = 0,35 \times 4 + 0,25 \times 4 + 0,40 \times 3 = 3,60$	
Objectives diagnosis	0,35	4
Strategy diagnosis	0,30	4
Internal organization diagnosis	0,35	4
Strategic management diagnosis	$MD = 0,35 \times 4 + 0,30 \times 4 + 0,35 \times 4 = 4,00$	

The main conclusions of this chapter are:

- C.5.1: The market value of CoPeL for the purpose of its sale is RON 17.000.000 / EUR 3.500.000 determined by the adjusted net asset equity method;
- C.5.2: Strategic market diagnosis has achieved an average result due to turbulence caused by pandemics and wars. These disruptions caused disruption to international supply chains. Strategic resource diagnosis performed well because a lot was invested in modern technologies and a valuable core of human resources was secured. The strategic management diagnosis achieved a good result because of the company's more than 70 years of experience in the German market. The company implements long-term policies and invests in the competitiveness of the products offered. The aim is to attract competitive human resources and offer quality jobs. The result of the final diagnostic analysis of CoPeL is good (closer to 4 out of 5), resulting from the calculation of the value of the final diagnostic analysis coefficient according to the agreed formula.

$$DA = 0,30 \times PD + 0,40 \times RD + 0,30 \times MD = 0,30 \times 3,30 + 0,40 \times 3,60 + 0,30 \times 4,00 = 3,63$$

Recommended strategy:

- continue to invest in modern and innovative AI-based technologies;
- development of the refurbishment department of logistics equipment using AI;
- reduction of resource consumption and CO₂ emissions using AI;
- continued development of management and marketing policies using AI.

Reducing costs by investing in AI will give the firm long-term competitive advantages. Although the firm's level of automation is good, this process needs to continue. AI can also be used to carry out interim assessments and diagnostic analyses. The rapidity of the results obtained with the help of AI must be confirmed periodically and by classical methods of assessment and diagnostic analysis.

CHAPTER 6. ELABORATION OF THE DEVELOPMENT STRATEGIES OF A LOGISTICS EQUIPMENT MANUFACTURING COMPANY (CoPeL)

The objectives of this chapter are:

- O.6.1: Elaboration of CoPeL development strategies;
- O.6.2: Highlighting the superior financial results of the two newly created entities following the split of CoPeL.

A risk management plan, a sales plan, a logistics plan and an investment plan will be developed.

Table 20. Identified risks

Category	Identified risk
Access	Physical access of unauthorized persons to company buildings
	Employee access to confidential information
	Employees access to information necessary for work efficiency
	The company's access to modern technologies
	Management's access to the latest advances in science
Availability	State-of-the-art equipment
	Human resources
	Financial resources
	Computer systems
	Management stability and performance
Infrastructure	IT system adapted to the needs of the organization
	Computer system failure
	Planning activities and organizational structure
	Research and development with ultramodern equipment
	Failure to implement AI
Integrity	Data validity and security
	Preventive control and error handling
	Change management and adaptation to the market trend
	Failure to meet the production plan
	Lockdown of supply chains
Relevance	Failure to meet delivery deadlines to customers
	Ineffective communication of information between departments
	The time of use of the information generated by the computer system
	Usefulness of the information transmitted by the computer system
	Failure to implement the provisions of the European Green Deal

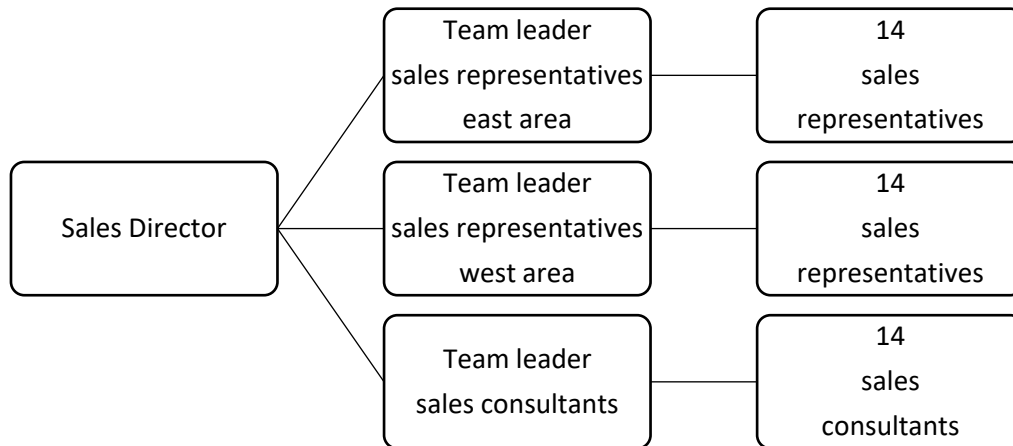


Figure 10. CoPeL sales team structure for 2023

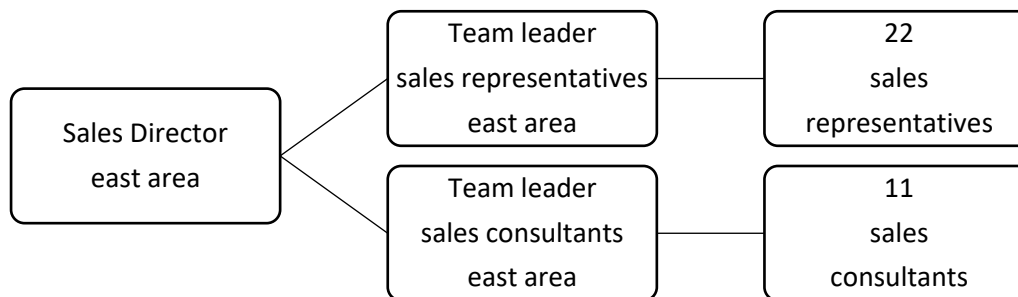


Figure 11. CoPeL sales team structure for 2027, east area

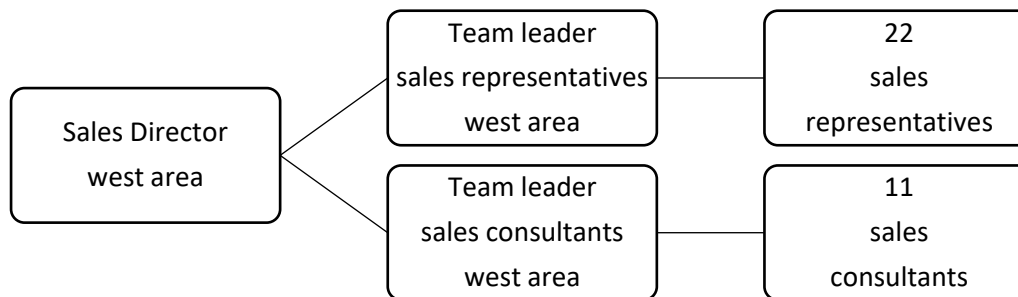


Figure 12. CoPeL sales team structure for 2027, west area

A plan will be made to optimise CoPeL's logistics system. Warehouses, CDs or logistics hubs can be energy independent. Autonomous and clean means of transport are sustainable although their cost is high.

Between 2023 and 2027, 1.000.000.000 lei will be invested. To evaluate the investment, a profit and loss account projection will be made, and a series of financial indicators will be calculated.

To calculate the internal rate of return (IRR), the investment value must be equal to the total discounted revenue value:

$$Investment\ value = \frac{TR_{23}}{(1 + IRR)^1} + \frac{TR_{24}}{(1 + IRR)^2} + \frac{TR_{25}}{(1 + IRR)^3} + \frac{TR_{26}}{(1 + IRR)^4} + \frac{TR_{27}}{(1 + IRR)^5}$$

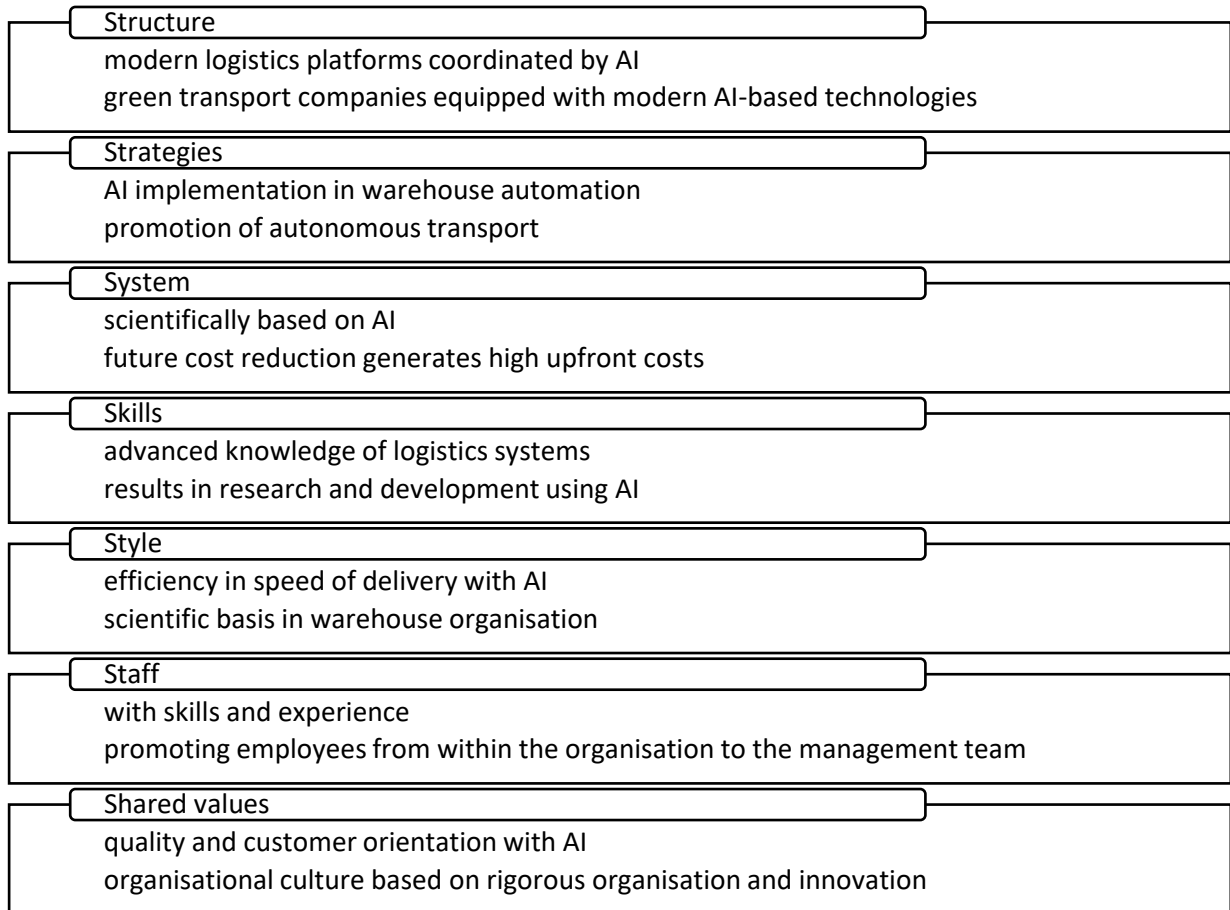


Figure 13. The McKinsey 7S model in the CoPeL logistics system

Calculations will be made for different values of the discount rate until the net present values closest to zero are found:

For DR_{\min} = 18%, results $NPV_{\min} = 23.523.440$

For DR_{\max} = 19%, results $NPV_{\max} = - 1.506.179$

The company has decided that starting from 2023, it will separate the activity of refurbishing used logistics equipment from the production of new logistics equipment. The aim is to streamline the activity, preserve the SME status and the related facilities for both newly created entities:

- CoPeL representing the manufacturing company of the new logistics equipment;
- CoReL representing the refurbishment company for CoPeL's used logistics equipment.

CoReL's own brand of refurbishing used electric forklift trucks with lithium-ion batteries is a sustainable solution to reduce resource consumption. The resulting product is almost as good as new in terms of quality. Refurbishing used industrial equipment will become a standard soon and will be the new global trend in developing cost reduction strategies. Complete and centralised refurbishment of used CoReL logistics equipment extends the life cycle of forklift trucks by 94% and reduces CO₂ emissions by 80% compared to the production of new electric forklift trucks. Using AI in the refurbishment process will improve CoReL's financial results.

Table 21. Profit and loss account projection for the years 2023 - 2027 (lei)

Indicator	2023	2024	2025	2026	2027
Turnover	248.653.930	287.153.900	335.723.812	374.218.090	428.906.523
Total revenue	254.623.920	291.563.005	342.783.020	383.092.578	439.526.830
Total expenditure	243.732.479	277.400.890	325.259.374	361.820.379	414.890.734
Net profit	9.148.810	11.896.177	14.719.863	17.868.647	20.694.321

Table 22. Financial indicators for investment evaluation

Indicator	2023	2024	2025	2026	2027
Investment value	1.000.000.000 lei				
$Profit\ rate = \frac{Net\ profit}{Turnover} \times 100$	3,68%	4,14%	4,38%	4,77%	4,82%
$Rate\ of\ return\ on\ investment = \frac{Total\ income}{Investment\ value} \times 100$	25,46%	29,16%	34,28%	38,31%	43,95%
Discount rate (DR)	7%				
Discounted annual income	237.966.280 lei	254.662.420 lei	279.813.052 lei	292.259.494 lei	313.376.555 lei
$Total\ discounted\ revenue = \frac{TR_{23}}{(1+DR)^1} + \frac{TR_{24}}{(1+DR)^2} + \frac{TR_{25}}{(1+DR)^3} + \frac{TR_{26}}{(1+DR)^4} + \frac{TR_{27}}{(1+DR)^5} = 1.378.077.801\ lei$					
Investment payback period	3 years 9 months and 11 days				
$Net\ present\ value\ (NPV) = Total\ discounted\ revenue - Investment\ value = 1.378.077.801 - 1.000.000.000 = 378.077.801\ lei$					
$Profitability\ index = \frac{Total\ discounted\ revenue}{Investment\ value} = \frac{1.378.077.801}{1.000.000.000} = 1,38$					
$Internal\ rate\ of\ return\ (IRR) = DR_{min} + (DR_{max} - DR_{min}) \times \frac{NPV_{min}}{(NPV_{min} - NPV_{max})} = 18,94\%$					

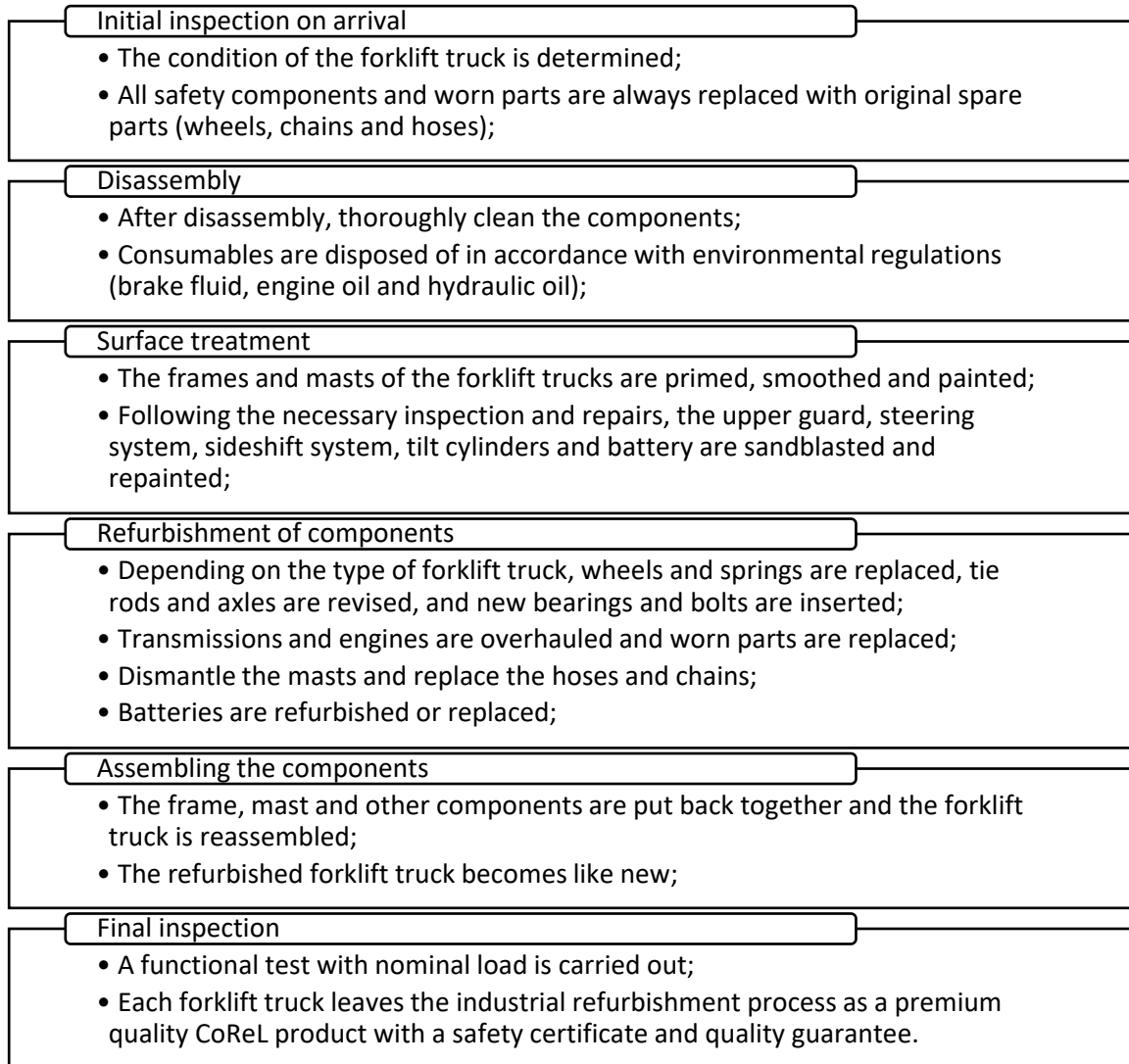


Figure 14. Stages of the CoReL electric forklift trucks refurbishing process

Table 23. Projection of the profit and loss account for CoPeL following the company split (lei)

Indicator	2023	2024	2025	2026	2027
Turnover	160.729.900	175.738.187	193.645.494	202.377.143	216.168.887
Total revenue	164.588.902	178.436.559	197.717.246	207.176.466	221.521.522
Total expenditure	157.236.697	169.103.583	186.516.735	194.167.288	207.113.454
Net profit	6.175.852	7.839.700	9.408.429	10.927.710	12.102.777

Table 24. Projection of the profit and loss account for CoReL following the company split (lei)

Indicator	2023	2024	2025	2026	2027
Turnover	90.410.569	117.158.791	152.150.032	186.809.671	234.182.962
Total revenue	92.581.257	118.957.706	155.349.265	191.239.815	239.981.649
Total expenditure	88.182.411	112.069.960	145.260.836	177.147.258	221.136.761
Net profit	3.695.031	5.785.707	8.474.280	11.837.748	15.829.706

The main conclusions of this chapter are:

- C.6.1: In developing CoPeL's development strategies, the main risks are management's access to the latest science and failure to deliver on the production plan. The main preventive measures are investment in research and development and management capabilities. The main contingency measures are technological innovation and flexibility in the production process. For the period 2023 - 2027, the sales team will be increased from 46 to 72 people. It will aim to double the sales budget and increase the share of investment in human resources from 50% to 58% of the sales budget. Through the method of activity-based costs, the direct and indirect costs of the resources necessary for the good functioning of logistics systems were highlighted: speed, AI implementation, profitability, efficiency and ecology. Through the method of activity-based management, the added value was highlighted in the optimisation of transport routes and in the efficiency of warehouses: stocks, handling, delivery planning, transport optimisation with the help of AI and autonomous vehicles. The benchmarking method ensured the comparison between different types of logistics platforms and means of transport: transport and modern warehouses, fast deliveries and optimal organization of warehouses, record of delivery times and financial flows, autonomous transport and equipment, implementation of AI in transport and storage. Through the McKinsey 7S model, support was provided in the evaluation, improvement and development of the logistics system with the help of AI: investment in research and development, innovation in the sphere of delivery planning and management of storage systems, automated logistics platforms and autonomous transports and ensuring quality services offered to customers. Modern investment financing opportunities will be implemented such as: crowdfunding, public-private partnership, venture capital and private equity. For the period 2023 - 2027, investments of 1.000.000.000 lei will be made by the parent company in Germany. It is expected to have a profitability ratio of 1,38 and an internal rate of return of 18,94%. Separation of the refurbishment of used logistics equipment from the production of new logistics equipment will be sought.
- C.6.2: The combined estimated financial results of the two newly created entities following the CoPeL split are higher than those obtained without the split.

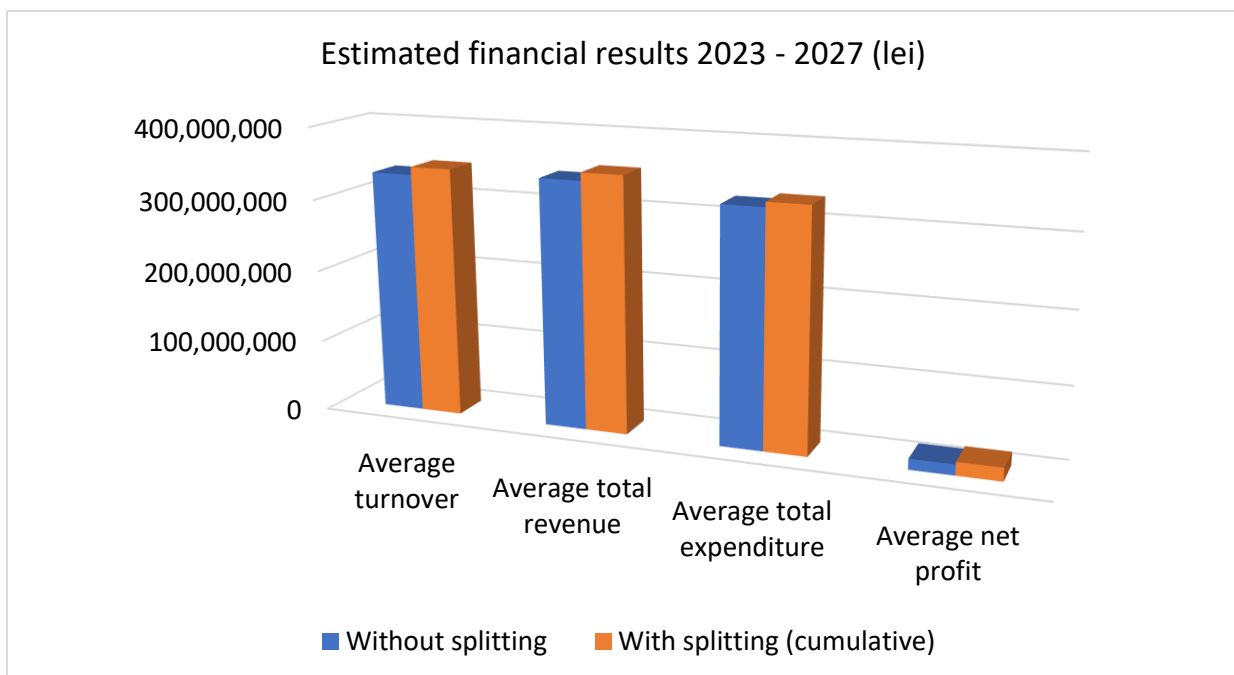


Figure 15. Estimated financial results for the period 2023 - 2027



CHAPTER 7. FINAL CONCLUSIONS. ORIGINAL CONTRIBUTIONS. DISSEMINATION OF RESULTS. FUTURE DIRECTIONS OF RESEARCH

CoPeL is part of the group of companies that revolutionized electrical logistics equipment by introducing lithium-ion batteries into their production for the first time. At first, they were introduced in the series production of electric pallet trucks and later in the series production of electric forklift trucks. The company has been involved from the beginning in the development of lithium-ion batteries for its own logistics equipment, reducing the price of lithium-ion cells tenfold. By switching from 48-volt to 24-volt technology, energy savings of up to 30% have been achieved. The technology has evolved so much that the lifecycle of lithium-ion batteries in some cases is like the lifecycle of the related logistics equipment. This means that in some cases lithium-ion batteries are incorporated into equipment. Although lithium-ion batteries cost twice as much as lead-acid batteries, they prove to be much more efficient in use. The lifecycle of lithium-ion batteries can be extended by refurbishing used ones. Compared to older lead-acid battery technology, we can conclude that lithium-ion batteries: are safer, have much lower maintenance costs, have a longer life cycle, weigh less, are easier to change, are two-thirds smaller, reduce the overall size of logistics equipment, create more space for operators, increase the safety and stability of logistics equipment, are more efficient and more sustainable, emit 21% less CO₂ and will be the most used by the end of this decade.

I looked at the sustainable development of a multinational company, a world leader in intralogistics solutions. It had its best year yet in the pandemic year 2021. The company has won numerous awards at various major events for the innovative products it has developed over the past few years. It was awarded best company in the international industrial product design competition Red Dot Design Award. The product presented was a logistics equipment that recognized when it was in a truck using an ultrasonic sensor. It automatically switched on the headlights to illuminate the loading area and automatically reduced the speed of the equipment ensuring more safety in the loading/unloading process. The company affiliated itself with the Science Based Targets group by committing to using only green energy. Most of its factories in Europe are equipped with solar panels. It aims to attract quality human resources by creating a digital working environment and the possibility to work from home.

The EcoVadis rating agency awarded the company a platinum certificate, representing the top 1% of more than 85.000 companies evaluated. It represents the highest level of sustainability and ranks the company among the world's most sustainable companies through: social responsibility, environmental responsibility, profitable growth, modern intralogistics services, innovative logistics platforms, its own labour and human rights code, sustainable procurement, commitment to the Paris climate goal of a 1,5 degree Celsius temperature reduction and the desire to achieve group-wide climate neutrality. The processes of digitization, globalization, openness to Asia, urbanization, density, climate change, resource scarcity, e-commerce, innovation, sustainability, electric mobility, integrated solutions, electric drive, automation, green economy and vertical farming in small spaces are promoted.

CoPeL has a competitive strategic management through the products and services it offers because: invests heavily in research and development, has a multinational organizational culture, has successfully overcome the supply chain disruption of the pandemic period, quickly finds alternative sources of supply, participates in social responsibility programs, donates annually to humanitarian actions, ensures increased logistics flow and automated logistics capabilities, improves productivity and increases warehouse security. CoPeL is growing rapidly in the areas of automation, digitization, energy systems, efficiency, pollution reduction and sustainability. CoPeL is looking to expand into the areas of electrical construction machinery, agricultural machinery and complete energy solutions. By 2025 CoPeL's objectives are: to achieve a turnover of more than €6 billion at group level, 25% of revenues to be from outside Europe, 80% of equipment to contain lithium-ion batteries, 30% of managers to be women and to ensure sustainability through climate neutrality at group level.



CoPeL's value has the potential for accelerated growth in the medium to long term, as it is part of a multinational group with over €5 billion turnover in 2023. The company specializes in state-of-the-art logistics equipment. Its star product is electric forklift trucks with lithium-ion batteries. CoPeL has stopped producing diesel-powered forklift trucks in the context of the increasing quality standards imposed by the European Green Deal. After the shock of 2020, the company grew accelerated in 2021 mainly due to massive investments in two refurbishment lines for used electric pallet trucks and used electric forklift trucks. Proximity to the market and customers is fundamental in ensuring the success of the business. Sales teams and customer relations teams have been developed through modern technological means and after-sales service teams. Meeting customer needs is paramount, especially by anticipating them. Experienced people have been attracted to the company who know the market and can offer solutions to improve the business. For the future, the research and development department is to be developed to help the company discover and implement new innovative technologies.

The most important risks identified from the point of view of qualitative risk analysis are: management access to the latest science, failure to meet the production plan, human resources, financial resources, management stability and performance. The most important risks identified in terms of quantitative risk analysis are: failure to meet the production plan, management access to the latest science, company access to modern technologies and state-of-the-art equipment, supply chain bottlenecks and failure to deliver to customers on time. The most important preventive measures are investment in research and development and management capabilities. The acquisition of technology companies or research and development institutes is also very important. The importance of human resources at all levels should not be neglected. Blockages in supply chains are the first factor that leads to failure to deliver to customers on time. Logistics optimisation and supply chain diversification at suppliers will ensure revenue growth. Technological innovation and flexibility in the production process are the most important contingency measures. Failure to meet the production plan is a high risk for the cohesion of the organization. Very important is the training and retention of highly experienced employees. To reduce costs, it is sometimes possible to outsource certain technological processes that are not used in high enough volumes. For dissatisfied customers the company will consider compensatory measures, financial or non-financial. If a customer has received a product late, as a compensatory measure it can be prioritized for a future delivery. It is very important to prevent unauthorized persons from entering the company. Investment in equipment is needed to automate the information system. To ensure data security, the information system needs to be managed optimally by specialized staff. Failure of IT systems to function optimally can create irrecoverable disruption to an organization. Massive investments in research and development laboratories are necessary to gain access to innovative technologies. It is necessary to attract and develop specialized human resources to ensure information management performance. Effective information systems are seen as an investment and not as a cost. The resources used are of high quality and CoPeL invests in state-of-the-art technologies.

CoPeL is ready for the implementation of the European Green Deal due to the very high-quality standards in the organization. There is no shortage of modern low-polluting technologies. The need for energy-efficient products with low CO₂ emissions will ensure the growth of turnover in the coming years. In the long term, additional investment will be needed as competitors will also invest heavily in research and development. The sales department carries out studies and strategies to effectively penetrate the market and promote the right products to each potential customer. The after-sales service ensures continuity of customer relationships. If all the provisions of the European Green Deal are not implemented at European level, this will mean that many companies will remain in the market offering low quality goods at a low price. In this context, the company will experience a potential drop in sales, which can only be compensated for by cutting costs. The possibility of not implementing the provisions of the PNRR on time is high. This will mean less investment in the national economy and therefore lower sales for the firm. Production volume may be jeopardized, and the production plan reduced. Purchases from suppliers will have to be reduced and the production plan of suppliers and sub-suppliers will also be reduced accordingly. Inflation will also increase by reducing economies of scale. As the volume of purchases is lower, the price per unit of product will automatically be higher. The implementation or non-

implementation of the PNRR provisions will generate positive or negative exponential effects. The effective implementation of the PNRR is also about the efficient allocation of human resources.

Decisions are taken on scientific grounds. They are sometimes covered by justifications and forward-looking calculations of benefits and costs. The management team is homogenous, with ongoing consultation, which ensures some consistency in planning. The decision-making system is long-term oriented, in line with international market developments. Investment in international strategic management knowledge ensures the implementation of decisions with medium to long-term benefits. Investment in a small range of products and quality is recommended. Preventive management and anticipatory marketing ensure better adaptation to market needs. Reorganization of managers tasks is needed to free up the CEO's schedule and transfer tasks to department managers. Involving top management in purely strategic issues will ensure the need for global vision and crisis prevention.

It is recommended to use international business consultants to implement a predictive information system of financial marketing strategies. Outsourcing some financial and sales services can lower costs. The company ensures that raw materials delivered by suppliers are not extracted through inhumane working conditions. CoPeL is concerned about the respect of the law and of moral and ethical rules by all collaborators. Automation of processes increases efficiency and reduces resource consumption. It is the first logistics equipment manufacturer to publish a product life cycle assessment.

In the production of products there is an invisible consumption of water as well:

- 130 litres of water for a cup of coffee;
- 3.850 litres of water for a 250g steak;
- 4.100 litres of water for a T-shirt;
- 8.000 litres of water for a pair of jeans;
- 7.000 litres of water for one CoPeL lithium-ion battery.

Lithium-ion batteries have a significantly longer life expectancy than a pair of jeans or a steak. Figures from the US Geological Survey show that the planet has huge reserves of lithium. These will last for 437 years under current mining conditions. A lot of water is consumed in lithium mining. In Germany, about 117 billion cubic meters of water are consumed every year, which is about 3.900 litres of water per person per day. Lithium is used mainly in ceramics, glass, batteries and lubricants. The share of lithium in batteries has increased by almost 10% per year in recent years, from 34.000 tons in 2013 to 65.000 tons in 2020. The number of lithium-ion battery logistics equipment sold by CoPeL exceeded 100.000 in 2023. Electric forklift trucks with lithium-ion batteries reduce CO₂ emissions by 52% compared to diesel-powered forklift trucks. For electric forklift trucks with lead-acid batteries this energy efficiency is only 42%. Lithium-ion technology is the technology of the future and lithium-ion batteries are sustainable. The refurbishment industry for used industrial equipment will become a standard in the future because: it helps to reduce resource consumption, extends the life cycle of equipment and ensures cost savings. CoPeL's research and development should also be directed towards other areas related to logistics equipment. It should be borne in mind that the company has now exceeded 20.000 employees at group level and the danger could be that large organizations tend to become more rigid than small ones. The energy sector is becoming vital in the long term and investment in own energy capacity can lead to energy independence. Job security needs to become a priority and investment in research and development in this area can lead to more secure jobs.

The defining features of the PNRR were presented through brainstorming and multi-criteria analysis. In the first two years of the COVID-19 pandemic, countries public debt increased rapidly. Some of the developed, northern European countries were sceptical and initially accepted only loans without subsidies. Although Germany was known as a country in favour of budget constraints, it changed its attitude and was in favour of the common EU debt and subsidies. Southern European countries, which had large budget deficits, were in favour of subsidies. Social, agricultural and environmental reforms will be implemented. Environmentally friendly green technologies will be promoted, leading to better air, water and food quality. Renewable energy together with recycling and re-use of products will become



standard. To ensure resilience, cohesion and sustainability there will be massive investment in digitalization, health and education. There is the possibility of accessing subsidies at no financial cost. These will ensure a better quality of products and services on offer but come with higher prices. PNRR will practically ensure the acceleration of the degree of European integration of Romania with the related advantages and disadvantages. As a developing country, Romania must copy the models of western countries. After becoming a developed country, Romania will have to find innovative solutions to develop further. The year 2022 represented a record for Romania in attracting European funds (over 11 billion euros) and foreign direct investments (over 10 billion euros). It was also an inflationary period where those who held bank deposits received negative real interest rates. Countries must generate budget surpluses in years of economic growth to compensate for budget deficits in years of economic decline. If this principle is not respected, the public debt risks getting out of control. The model to follow is that of budget balance. Unfortunately, developed countries have a high level of debt and developing countries are copying their wrong model. Globalization means that in the long-term countries become relatively equal and the differences between them decrease. We can imagine in the long run a planet governed as an independent country, the differences being made only by the existing resources at the level of each region. It is important that the optimisation of resources is done gradually, so as not to generate asymmetric shocks. For example, if all the inhabitants of a poor country moved to the rich countries, then the poor country would be left without the human resources capable of helping it develop.

Supply chain management will consider reducing resource consumption. AI will optimise the procurement of raw materials, the efficiency of production processes and the quality of finished products. Production costs represent a maximum of 25% of the selling price. The rest is research and development, logistics, marketing and waste management expenses. Managerial strategies establish the directions to follow, and the resources needed to achieve the proposed objectives. Competitive advantages derive from low costs, high quality and differentiated products. Business partners are just as important as your own employees. Value is different from price and the value of products must increase more than the increase in prices. Almost 70% of German companies believe that satisfying customer needs by being close to them is as important as technological development. The long-term trust and guarantee offered to a customer ensures increased profitability and the loss of a customer generates cascading losses. Every year the planet uses more than 50% more resources than it can produce. Income is distributed inequitably among the owners of the factors of production. Labor and nature are valued less than holders of capital and information. Reducing inventory related to purchases and delivery is the main way to reduce costs in the manufacturing activity, followed by flexibility in the production process in case of supply chain disruptions.

From the perspective of logistics optimisation AI will make many jobs disappear in the coming decades. Self-driving cars will make the job of driver disappear. Autonomous forklift trucks will make the forklift operator job disappear. Likewise, many operator jobs of various machinery and equipment that will have AI embedded will disappear. Many tasks of transport coordinators and warehouse planners will be taken over by AI. In these areas people will only be needed in exceptional situations. It will be interesting to see how the borderline decisions will be made by humans who don't have enough experience in these areas, with the work being done by AI. There is a risk that some of their wrong decisions will erode from the profit provided by AI. However, new jobs will appear both in the field of development and in the field of AI implementation. Logistics will be totally transformed thanks to AI. There will also be huge implications in the field of vehicle and equipment maintenance. AI will be able to provide real-time information about their condition and when they will need to be addressed. The machines used in maintenance will also be coordinated by AI, the role of humans being reduced. Autonomous vehicles will benefit from both their own AI systems and fleet management systems that will coordinate their future routes. Autonomous logistics equipment efficiently handles pallets of goods inside logistics platforms. Warehouse management systems will coordinate logistics equipment and optimise warehouse space. The stock management system and the placement of goods in warehouses will be simplified for quick unloading and loading of trucks. Automated delivery planning will help shorten delivery times for goods.

Autonomous trucks and autonomous logistics equipment will be able to work continuously, unlike human operators who have a work schedule of only 8 hours a day. The battle will be won by AI driven cars. Jobs

will also undergo changes. It is very likely that the normal working hours of the employees will decrease to only 4 days per week, to ensure a sustainable level of unemployment. With the further development of AI, following investments in research and development, it is likely that the normal working hours of humans will decrease to only 3 days per week. At this rate, the hourly productivity of human resources will be higher than at present, because the days of rest will be more than the days worked.

This thesis presents an innovative approach to the strategic implications of AI on the optimisation of logistics systems. I analysed 205 bibliographic sources in the field of AI, logistics management, procurement management, multicriteria analysis, brainstorming, the innovative ESG-AI-BSC model, the assessment and diagnostic analysis of enterprises, risk management, investment management, financial management and innovative management. I have outlined the contributions and limitations of the 50 relevant bibliographic sources that contributed to this paper. These were selected based on the following keywords: AI, logistics optimisation, supply chains, strategic management and sustainable development (chapter 1).

From the perspective of logistics management, I analysed the transport and storage components. From the perspective of transport, I analysed the road transport of goods by means of TIR category trucks. This type of transport dominates the logistics market in Romania. From a storage perspective, I analysed CD services through three models: simplified, complex and optimised. CD services are the most dynamic sector of logistics platforms. They help reduce the total costs of delivering goods by optimising logistics chains (chapter 2).

From the perspective of procurement management, I analysed the selection process of suppliers within a procurement department of a multinational company, as well as the digitized procurement process. I evaluated the offers of metal construction, hand tools, wooden pallets, electricity and natural gas suppliers. I presented a procurement IT program and the stages of the procurement digitization process. I detailed the procurement processes from sending requests for quotation to potential suppliers and registration of offers received in the IT system to making the decision on the most suitable supplier and sending the purchase order to him (chapter 3).

I made applications of the multicriteria analysis, the brainstorming method and the innovative ESG-AI-BSC model. I analysed the PNRR from the perspective of PhD colleagues in engineering and management of Transilvania University of Brasov. I evaluated the purchasing and sales management within CoPeL. I highlighted the implications of the innovative ESG-AI-BSC model on logistics management. From the perspective of PNRR, as a component of NGEU, I highlighted the need for such a post-pandemic funding program. The EU's joint loans reduce financing costs, but rigorous bureaucracy makes money hard to access. The analysis of procurement management within CoPeL reflects the need to optimise the internal organization. The development of the procurement department depends on respect for employees and the implementation of scientific models. The analysis of sales management within CoPeL reflects the promotion of modern technology of electric logistics equipment with lithium-ion batteries. Abandoning the production of polluting equipment and being close to customers will ensure the growth of image and market share in the future. The innovative ESG-AI-BSC model will revolutionize logistics management. More and more autonomous vehicles and fully automated logistics platforms will be developed. The human workforce will only have the role of supervising and maintaining the equipment. AI will ensure the prevention of natural disasters, help increase social cohesion by eradicating poverty, and optimise managerial decisions with the help of artificial management. Education will be digitized and personalized. Customers will have easier access to information about the resources used in obtaining each product. The return on capital will be optimised by reducing costs (chapter 4).

I performed the assessment and diagnostic analysis of CoPeL. I determined the market value of CoPeL for the purpose of selling it. To carry out the final diagnostic analysis, I carried out the strategic diagnosis of the market, resources and management of CoPeL. I carried out the assessment using the equity methods of the net book asset and the adjusted net asset. The market value for the purpose of the CoPeL sale is 17.000.000 RON / 3.500.000 EUR. To carry out the diagnostic analysis, I calculated an aggregate coefficient of the strategic diagnosis of the market, resources and management. The diagnostic analysis of the market

received an average rating and that of resources and management received a good rating. The final diagnostic analysis of CoPeL received a good rating (chapter 5).

I developed a development plan for the company. As part of it, I created the risk, sales, logistics and investment management plans. I carried out a company split to preserve the SME status for both entities. From the perspective of qualitative risk analysis, management's access to the latest scientific achievements must be stimulated. It can be prevented by investing in research and development. The effects can be reduced through technological innovations. From the perspective of quantitative risk analysis, great attention must be paid to the risk of failure to meet the production plan. It can be prevented by increasing managerial capabilities. The effects can be reduced by making the production process more flexible. The increase in the quality of the sales team will be achieved by increasing the funding per employee and by developing the management team. CoPeL's logistics system optimisation plan is based on the methods of activity-based costing, activity-based management, benchmarking and the McKinsey 7S model. Activity-based costing will focus on: speed, AI implementation, profitability, efficiency and ecology. Through the method of activity-based management, the following will be made more efficient: stocks, handling, delivery planning, optimisation of transport with the help of AI and the use of autonomous vehicles. The benchmarking method will ensure: modern transports and warehouses, fast deliveries and optimal organization of warehouses, record of delivery times and financial flows, transport and autonomous equipment, implementation of AI in transport and storage. Through the McKinsey 7S model and with the help of AI, investments will be made in: research and development, innovation in the sphere of delivery planning and management of storage systems, automated logistics platforms and autonomous transports and ensuring quality services offered to customers. I recommended modern financing opportunities adapted to the logistics equipment industry such as: crowdfunding, public-private partnership, venture capital and private equity. I have divided the company into two entities, one that will deal with the production of new equipment and another that will deal with the refurbishing of used equipment. In the end the division of the company has led to better cumulative financial results of the two newly created entities (chapter 6).

It can be concluded that the presented work can be used as a reference manual for managers of companies operating in the logistics sector. AI will revolutionize society in general and logistics in particular. Autonomous vehicles will also lead to a decrease in the number of vehicles on the road. The truck drivers schedule makes each single-driver truck operational 45 hours per week. By implementing AI a truck will be able to be operational up to 168 hours per week.

The advantages of this research are the innovative ideas applied to improve the current logistics systems. The contributions of this research relate to the improvement of the logistics sector as a whole and complementarity with current and future technological innovations in the field of AI. The limits of the research are related to the limits of the methods used. The work is limited to: truck transport and CD logistics platforms; the choice of suppliers for a small number of elements necessary for the good functioning of the company; presentation of a simplified process of digitization of purchases; multi-criteria analysis, brainstorming and the innovative ESG-AI-BSC model have the role of highlighting the ideas presented in a not very complicated manner; the assessment of CoPeL was done by equity methods without taking into account the detailed separate assessment of each component; the diagnostic analysis has been simplified to reach the final result more easily; the development plan includes only the risk, sales, logistics and investment components. The investment plan is the most complex and demonstrates the importance of separating activities within the group. Considering the preservation of the SME status of the companies in the group, superior financial results can be obtained in the end.

As first author, I have published:

- a scientific paper entitled "From COVID-19 Pandemic to Next Generation EU" in "Recent Journal" 66 - number 1/2022, volume 23.
- a scientific paper entitled "Advantages and Disadvantages of the National Recovery and Resilience Plan" in "Recent Journal" 67 - number 2/2022, volume 23.



I participated in the "8th International Management Conference - Review of Management and Economic Engineering", September 22 - 24, 2022, Cluj-Napoca. The conference volume has been submitted for indexing to Web of Science (ISI). The conference volume was indexed in Zenodo, Switzerland (BDI). As the first author, I published two scientific papers in "Proceedings of the 8th Review of Management and Economic Engineering - International Management Conference - Management Challenges and Opportunities in the Post-Pandemic Reality", entitled:

- "Dynamic Capabilities and High-Quality Standards in S.C. Jungheinrich Romania S.R.L." – pag. 44-49;
- "Electric Forklift Trucks Refurbishment at S.C. Jungheinrich Reconditioning Romania S.R.L." – pag. 50-56.

I participated in "The 10th edition of Strategica International Academic Conference - Sustainable Development and Strategic Growth", October 20 - 21, 2022, Bucharest. The conference volume has been submitted for indexing to Clarivate Analytics (ISI Proceedings). As the first author, I published two scientific papers in "Conference Proceedings Repository - The 10th edition of Strategica International Academic Conference - Sustainable Development and Strategic Growth", entitled:

- "Strategic Ideas for Improving the Format of FIFA and UEFA International Competitions" – pag. 423-434;
- "Towards a Holistic Optimisation of the European Inter-Club Football Competition System" – pag. 435-444.

As a co-author, I have published:

- a scientific paper entitled "Security Challenges from the Integration of AI with Blockchain" in "Recent Journal" 69 - number 1/2023, volume 24.
- a scientific paper entitled "Medical Management of Blockchain, Patients, and Clinical Studies" in "Recent Journal" 70 - number 2/2023, volume 24.
- a scientific paper entitled "Market in Medical Devices of Blockchain-Based IoT and Recent Cyberattacks" in "Korean Journal of Artificial Intelligence" - number 2/2023, volume 11.

Future research in the field of logistics will focus on the implications of AI on all existing types of transport, logistics equipment and logistics platforms. In the sphere of procurement, the use of AI in the analysis of suppliers will be researched for as many components as possible necessary for the good performance of the activity. In the scope of the digitization of the procurement process, the takeover by AI of the entire procurement process will be analysed, with human intervention becoming minimal. Research will be expanded on the innovative ESG-AI-BSC model, which will bridge the generations before and after the advent of AI. The implications of AI in the assessment and diagnostic analysis processes of companies will be analysed. The role of specialists in the field will be to check the documentation and to sign the results obtained in their own name. The ability of AI to develop effective plans for the development of organizations will be analysed. AI has the potential to develop complex risk, sales, logistics and investment management plans. AI can provide modern solutions, financial calculations and recommendations towards optimising internal processes. AI will provide optimal solutions for the use and reuse of resources. The analysis of the implications of AI will be extended to other research areas. Other AI-recommended models will be used to optimise the results obtained.

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