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Streamlined Resilient Post-COVID-19 Supply Chain in Industry 4.0: A Case Study on Romania

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Abstract: The COVID-19 pandemic has accelerated the digitization of the logistics industry, exceeding the expectations of some companies. Ensuring customer satisfaction throughout the online ordering and delivery process has major implications for their profitability and market position. This study aims to classify firms in the logistics sector based on their financial accounting performance and determine if software designed for the logistics sector can improve their performance. By using advanced data analysis methods such as cluster analysis and neural network training, the study identifies three distinct classes. One company from a lower class was given a scenario for implementing digitization, improving its performance indicators, and enabling its movement to a higher class. The practical implications of the study are related to the domestic and international business environment, providing an overview of the logistics sector in Romania and a direction for growth for companies operating in the sector.

Keywords: logistics; data analysis; ODOO; inventory; data mining; neural network; SMEs

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1. Introduction

The SARS-CoV-2 health crisis and subsequent global shutdown have had a profound impact on consumers' behavior and supply chain performance. The already struggling global supply chains faced additional challenges due to the restrictions imposed by the pandemic. These changes have also affected the reporting of vendors and manufacturers in terms of on-time and in-full deliveries. Online purchasing has become the new norm, highlighting the need for goods to be readily available and easily delivered to customers. The closure of borders and disruptions in shipping, air, and road transport further exacerbated the situation, with overseas suppliers being replaced by domestic alternatives, if available. These factors have put significant pressure on small- and medium-sized enterprises (SMEs) to adapt and survive in these unprecedented times.

Overall, the pandemic has fundamentally reshaped consumer behavior, purchasing methods, and supply chain dynamics on a global scale. To add more pressure on SME survivability, the supply chain decision factors faced a new challenge that previously existed but has remained a non-priority issue in terms of internal matters problem-solving: reverse logistic goods management. In order to prevent the decline from a high-performance class company to a low-performance class company, the logistic management decision factors have been struggling to ensure up-to-date stock fluidity on warehouse racks and pallets and within the Enterprise Resource Planning and Warehouse Management System software through streamlined inventory in the context of this new commercial environment.

The COVID-19 pandemic has led to a surge in product returns, along with the usual ease of return sought by consumers. As a result, there is a need to improve the reverse

logistics process, particularly in terms of outdated IT systems that can cause bottlenecks in last-mile logistics. The retail ecosystem in Romania, which is struggling due to the crisis, is also calling for simplification and the streamlining of supply chain flows, including the handling of returned products and documents, as well as the use of equipment for online purchases. Furthermore, the shift from traditional business methods to online sales and customer relationships has posed a new challenge for IT mapping in both direct and reverse supply chains, particularly regarding software scalability. Overall, there is a demand for more efficient and adaptable systems to enhance the performance of logistics processes in the face of changing consumer behavior and market conditions.

Sultan et al. [1] explain that software scalability can be a main player in the technological barrier, already found under the magnifying glass of supply chain decision factors in the transition to Industry 4.0 and 5.0, because when the size and complexity of supply chain operations increases, the need for time-critical decisions increases also, and the software systems must grow and develop at the same rate.

Due to the COVID-19 lockdown in 2020, the overall e-commerce sector increased from 15% in 2010 to 35% in 2020 [2], and the continuous need for supply chain innovation to adapt to a structurally changed consumer behavior became a compulsory axis to look up to in terms of SMEs survivability. According to Eurostat statistical data [3], the proportion of e-shoppers grew from 55% in 2012 to 75% in 2022. Thus, the need for a better and less expensive way of goods transportation in order to ensure a fast and ecologically friendly hand-off to customers has amassed massive focus.

The rise of online shopping, fueled by the inability of customers to shop in traditional stores, has led to a surge in product returns. Customers are taking advantage of the easy return policies implemented by national authorities, allowing them to return goods without penalty or explanation. This has created a need for small- and medium-sized enterprises (SMEs) to efficiently handle returned products, regardless of the condition or cost involved. As a result, the transportation industry has become a crucial element in the resilience of SMEs in adapting to the shift towards online shopping and increased product returns. However, this has also put a financial burden on SMEs, requiring them to employ innovative strategies to manage product identification data, such as serial numbers and expiry dates, and implement logistics methods like FIFO, LIFO, and FEFO to effectively handle returns. Ultimately, SMEs must find ways to streamline the return process to remain competitive in the online market.

The digitization of small- and medium-sized enterprise (SME) supply chains is crucial in the current e-commerce landscape. This digital transformation encompasses various aspects, including online stock availability, product sharing, returns, and packaging reuse in the circular economy. To effectively manage these operations, enterprises rely on data analysis through software such as Enterprise Resource Planning, warehouse management, and customer relationship management. These tools allow businesses to track and enhance customer satisfaction, ultimately leading to improved financial performance. This shift towards online purchases has also resulted in a significant increase in goods being transported to customers via road transport vehicles. In Romania, there has been a notable rise in the transport of goods by road vehicles, with the number of tons per kilometer increasing from 266,523 tkm in 2020 to 306,777 tkm in 2021 and 324,526 tkm in 2022, according to the National Institute of Statistics [4].

Ever since, SMEs have started focusing on shifting from traditional fuel to electric vehicle usage, passing into green logistics, becoming a financially efficient medium for economic performance empowerment, and adopting an overall environmentally friendly image.

Thus, in addition to having an up-to-date stock accuracy, another challenge emerged in terms of the transportation costs for direct deliveries and returns, Wang et al. [5] explained that overall, the cost of last-mile delivery can become astronomical; as per data analysis, the last-mile cost can be up to 50% of the total logistics costs.

The COVID-19 pandemic has posed many challenges for businesses, particularly in terms of increased logistical costs. However, another significant factor to consider is the

prevention of the transmission of the virus [6]. This has led to warehouse responsibilities such as quarantining returned products and implementing sanitization protocols before they can be returned to stock for resale. Additionally, small- and medium-sized enterprises (SMEs) are also focusing on streamlining internal processes to adapt quickly to the changing global market. It is essential for cross-departmental employees to understand their roles and responsibilities in order to implement innovative strategies and compete effectively in the market. Overall, businesses are facing the dual challenge of managing logistical costs and preventing the spread of COVID-19 while also striving to improve efficiency in order to stay competitive.

Therefore, the impact of the COVID-19 pandemic [7], when deeply analyzed, helps remap the supply chain software blueprints as SMEs became aware of the software dependency on time, accuracy, financial resources, and future growth scalability for empowering a resilient and competitive supply chain.

This study aims to classify firms in the logistics sector based on their financial accounting performance and determine if software designed for the logistics sector can improve their performance.

The main research questions (Q) that the authors considered in conducting this study were as follows:

Q1: How can companies in the logistics sector in Ilfov County be classified according to their financial accounting performance?

Q2: Can firms' performance be improved; in other words, can they be moved from a low- to a high-performance class by using software developed for the logistics sector?

In order to answer the above questions, the authors classify companies that are engaged in other transport-related activities, in particular logistics-related activities, combining advanced classification techniques with elements of artificial intelligence. Using advanced pattern recognition techniques, the companies will be classified into three distinct classes according to all the indicators considered in the study. In the second part of the article, after analyzing the activity of a firm from a lower class, it is proposed to introduce specialized software suited for the specific enterprise with the aim of improving its activity and moving to a higher class. Thus, by introducing digitization, a company's activity will be made more efficient, and indicators will be improved at the end of the study period.

The scientific paper has the following structure: introduction; literature review, in which the current state of knowledge of the subject is overviewed; description of the methodology and methods used in the research; main results found after applying the methodology; discussion based on the results found and description of the software chosen; conclusions and references.

2. Literature Review

It is no secret that the COVID-19 pandemic has affected businesses across the globe in various ways. The researchers have included environmental, social, and governance factors (with emphasis on adopting green technologies) in their study, as it is their belief that these factors influence the recovery of the affected supply chains. The authors concluded that promoting and implementing a green supply chain and green technologies will result in green products, which will allow the companies to enhance brand value, gain access to new markets, and consequently increase their profits [8].

Although the majority of researchers and practitioners consider the COVID-19 pandemic to be the biggest source of disruptions for companies, the reality is that companies and national economies constantly suffer from disruptions, whether it is the transition to Industry 4.0 and 5.0, climate changes (which brought along changes in consumers' behaviors), conflicts in different parts of the world, and so on. As such, according to the researchers' conducted study, companies should deal with these chain disruptions by protecting against future negative interference by constantly improving the supply chain in order to better cope with future challenges. The chains' resilience should be based on analyzing and

identifying the possible weak points that can lead to future disruptions on the one hand and the development of supply chains' capabilities on the other [9,10].

According to SAP (a multinational corporation that offers digital solutions for companies across the world), supply chain resilience represents its capacity to resist and recover from the majority of situations that negatively impact companies. In this case, the COVID-19 pandemic had a major influence on all types of businesses. Having a resilient supply chain allows companies to mitigate most of the risks that can occur in and negatively affect supply chains [11].

There are authors that have introduced the idea that supply chains are subjected to the constructal law, which is at the base of evolution, which means that there is no need for "human intervention" as the global supply chains that were recently disrupted by the COVID-19 outbreak will evolve in such a manner that future crises will not inflict as much damage as the current one had. This hypothesis is supported by two interviews with senior vice-presidents that the researchers included in the paper [12].

A resilient supply chain that can overcome the shortcomings of a health crisis like the COVID-19 outbreak is key to any successful business, and it is crucial in pharmaceutical companies. The authors tried to reveal the shortcomings of the pandemic-impacted pharmaceutical system in Namibia and concluded that the crisis made it even harder to access essential medicines for both the public and the private sector due to bureaucratic bottlenecks and the lack of emergency readiness [13].

During the COVID-19 pandemic, managers faced ten crucial challenges. Among these, the most important were the inconsistency of supply, suboptimal manufacturing, vehicle unavailability/delays, and delays in delivery. These factors caused even more damage to the supply chains in the emerging countries. The study's conclusions are that the inconsistencies in the supply chain, as well as the suboptimal manufacturing, are the most important sources of disruptions in the supply chain. As a result, the authors create guidelines to better manage businesses in the post-pandemic context by creating a resilient supply chain [14].

Unfortunately, many business managers are not fully aware of all the companies' objectives, which is crucial in the decision-making process. As such, when companies faced the restrictions imposed by the governments in order to limit the spread of COVID-19 and all economic activities took a big hit, managers had to make important strategic decisions that would ensure their companies' survival. Therefore, the researchers conclude that identifying the relevant objectives for each company that must be aligned with their supply chain and with the government is key when facing crises that can threaten the company's survivability [15].

The COVID-19 pandemic affected the decisions the supply chain managers had to make in order to limit the negative effects on their businesses. The study conducted on 282 retail employees from the UK perishable goods market revealed that the pandemic affected these activities despite all the proactive and reactive measures taken by the managers. The conclusion is that the most effective tools that managers could use for all company types (although it was shown that larger companies are more successful in applying risk management strategies) are innovation in the supply chain and empowerment [16].

Although reshoring involves a certain degree of risk, which is well documented in the literature, it is also considered a viable option to increase supply chain resilience in times of crises, like the pandemic. This strategy allows companies to diminish their reliance on foreign or global suppliers. The study's conclusions iterate that this strategy is more efficient during crises, as it is a very complex managerial technique, both for decision-making and implementation as well. As such, other options like diversifying the suppliers' portfolio or supplier collaboration can be used to overcome the shortcomings [17].

Although global crises, like the pandemic, the transition towards Industry 4.0, and climate change affect all companies throughout the world, there are some differences depending on the studied economic sector. The research points out some directions in supply chain management during the pandemic by studying three economic sectors: automotive,

IT, and home furnishings. The findings reveal that depending on the economic sectors, the managing techniques may vary. For the automotive industry, applying centralized management techniques for everyday operations will be the key to success. The IT sector needs to reduce its dependencies on a single region (in this case, China) and try to create a relationship with local suppliers as well in order to mitigate the crisis' effects on its supply chain. Lastly, for the home furnishings industry, the solution is to have more vertically integrated companies that will allow them to avoid any potential issues during the crises [18].

When analyzing the implications of the COVID-19 pandemic on the supply chain for multinational corporations in the fashion business, one must take into consideration all the important aspects: the known historical risks, the new types of risks that arose with the recent outbreak, as well as the proper ways to mitigate all those risks. The conclusions reveal that one of the fashion industry's downfalls is the offshoring strategies, which move production to countries or regions that offer the lowest production costs. During normal times, this is a winning strategy, but during crises (like the pandemic), this is a weak point, and the supply chains' disruptions were severe [19].

The supply chains in the British meat processing industry were heavily affected by the crisis, and the need to find new strategies to strengthen them became a priority. A much shorter chain that consists of local or regional partners is a strategy that will ensure the chain's strength. Furthermore, introducing digitalization, in the form of automation, for certain processing will further increase the capacity to resist potential crises [20]. The authors concluded that although these strategies will ensure a much more resilient supply chain, they will, unfortunately, mostly favor large-scale food systems.

The restrictions imposed by the governments as a response to the pandemic meant that consumers had to change their buying habits, e.g., transitioning from in-person shopping to online shopping. This shift translated into unprecedented changes at all levels, especially within the supply chain. The grocery and food shopping sector was the first to witness this change as it satisfies the most basic human needs. The study conducted on the Canadian grocery and food sector focused on three major impact factors for the supply chain: 1. price sensitivity in online shopping, 2. sustainability-motivated factors, and 3. the loss of sensory experience in online shopping. As the consumers benefited from the advantages of online shopping for food and groceries during the pandemic, it was only natural they would continue with this behavior. As such, the researchers conclude that the supply chain must be more responsive and strategic in any of the studied directions or all of them at the same time [21].

As only three of the fifty states of the US are responsible for 75% of the products that are consumed in the country, it can be said that the agro-food business is highly centralized. As a result, the pandemic has hit this sector hard, as it performed like any other long-chain supply business. As such, decentralizing this sector by creating food hubs that translate into much shorter supply chains will translate into benefits for the local farms, the end consumers (as the shipping costs are declining), and the environment as well since there would be a reduction in polluting emissions generated by transportation. Other benefits of this solution are the reduction of food waste, as people tend to buy less (since they have a closer produce source that is more reliable in terms of inventory), and better water management. It is important to mention that social sustainability will be positively impacted as well, as these food hubs offer access to fresh products, not only to end consumers but to social institutions, like schools and hospitals, as well [22–25]. The Romanian agro-food sector had suffered from the pandemic in a very similar way. The supply chain disruptions created massive losses as the population had to abide by the government's restrictions. As a result, the solutions to overcome these shortcomings were the reduction of dependencies on imported agricultural goods and the creation of new commercial relationships with local farmers in order to have shorter supply chains. At the consumers' level, the pandemic and all the restrictions that came along with it created

a new pattern for the vast majority of the population, namely, the transition from offline shopping, especially for food, to online shopping.

After the COVID-19 pandemic hit the Norwegian economy, just like in any part of the world, the majority of companies were closed, except the ones in the food and pharmaceutical sectors. Nonetheless, they were also affected by the outbreak, as the customers' demand changed and their pre-pandemic contingency plans could not be implemented due to the lack of details. According to the researchers, the conclusion was that in order to better withstand future disruptions, whether they are pandemic-related or not, companies should create more detailed contingency plans and strategies. A successful strategy would be to rely less on a centralized warehouse and use more storage facilities, which would reduce the impact of future disruptions [26].

As mentioned before, although the pandemic affected the entire world's economy, the strategies to mitigate its negative effects may vary from one system to another. For instance, for the Pakistani economy, management innovation, information processing capabilities, as well as knowledge management capabilities are the best strategies and capabilities for the supply chain to overcome the past sanitary crisis [27].

During the first half of 2020, the automotive industry was heavily affected by the plummeting sales as a result of the restrictions. As such, some of the supply chain companies (mainly the semi-conductor manufacturers) had to shift from the automotive sector to the IT&C sector, which witnessed an increased demand for smart devices. So, when the demand for new cars increased in the second part of 2020 and when the restrictions were lifted, the semi-conductor suppliers could not cope with such a demand. The semi-conductor crisis, as it was called, was the consequence of two factors: one was the short-term chain disruption, and the other was the long-term structural characteristics of the semi-conductor industry. According to the authors, the European automotive industry, both in general and with particular regard for the German automotive industry, had a small influence on the semi-conductor supply chain, but they were heavily affected by it. In conclusion, the researchers propose that logistical strategies should be adopted by the industry, along with new purchasing, an increase in warehouse capacity, and dual sourcing (especially for the critical components), in order to prevent future disruptions in the chain [28].

As the pandemic hit Malaysia, the manufacturing industry had to struggle with high demand, an insufficient workforce, lockdowns, and major disruptions in supply chains. As a result, with this paper, the authors offer a new way of managing a pandemic in today's business environment and determine that viable supply chain management techniques can improve a company's viability in a pandemic context [29]. Another successful strategy for the automotive sector would be the implementation of digital solutions for the supply chain, which, according to [30], will result in a more flexible chain, not only during crises but during normal times as well.

Recovering from the pandemic-induced crisis, economies have to follow a set of rules in order to mitigate the impact of after-shocks. At the micro level, for the supply chains, these types of effects are disruption tails and consist of the accumulation of orders and backlog. These negative effects are presented in a certain context when production and inventory are in a state of high instability. The researcher has concluded that supply chain coordination, along with gradual capacity ramp-ups, stands for efficient managerial techniques that alleviate the post-crisis impact on the supply chain [31].

Another managerial technique that positively impacts the supply chain is resource orchestration. However, few, if any, researchers have advanced the idea. Also, chain resilience is achieved by prioritizing supply chain alertness as one of the most important techniques to achieve the objective [32]. Although these findings have been successfully tested "in the line of fire", they were only solutions for the short term, so the authors concluded that researchers and practitioners alike trying to find long-term solutions, like bridging activities that expand collaboration between supply chain partners, is the long-term solution for increased supply chain resilience [33].

Some authors have created a series of resilience factors that will allow for better targeting of future measures for strengthening the supply chains. The categories are technology and people, sourcing, customer, ecosystem, and financial assets. Moreover, the researchers have shown that a more proficient supply chain management will allow far better responses to exterior stimuli (crises of any kind) [34].

Another important direction for improving the supply chain's strength is investing in digitalization. This will create a more resilient chain that will ensure smaller-scale disruptions, if any, if future crises arise. Furthermore, the authors offered six strategies to further strengthen the supply chain, all based on the COVID-19 pandemic experience, and they refer to supply chain stress tests and risk–recovery contingency strategies, increasing chain flexibility, supply chain visibility, the collaboration between supply chain members, and so on [20,35]. Since using digital technology assets for supply chains is considered to be a good method to reduce the pandemic's negative impact on a company's operations, a new problem arises for researchers and practitioners alike: whether the quantity of such assets influences the degree of success. As such, the research focuses on two dimensions of digital assets, namely, breadth and depth, which reveal the scope and the scale of these assets. The results of the research have shown that supply chain visibility is improved both by the breadth and depth of assets, while supply chain agility was improved by the depth of digital assets. Overall, both characteristics of a supply chain, visibility and agility, are important factors for the performance of a supply chain in crises [36].

For the construction sector, the COVID-19 pandemic has probably been one of the worst crises since 2007. The construction sector is highly vulnerable to health pandemics, budget overruns, poor information coordination, insufficient management oversight, and error visibility to stakeholders. So, managers had to find new ways to keep their business afloat. One way of achieving that goal is to adopt new technologies in the form of drones and robotics. For the researchers, the conclusion is clear: the impact of using the new technologies in construction is significant as it helps with inventory accuracy and increases cost efficiency [37,38].

An example of the successful adoption of technology within the supply chain is Brazil, a developing economy. During the pandemic, the Brazilian economy witnessed a massive increase in new companies' registrations specialized in e-commerce. Due to the restrictions implemented by the national government, online business was the only way to conduct business. The study's conclusion is that the shift in consumers' preferences allowed the majority of the newly created businesses to thrive and to lay the foundation for future development even after the pandemic ended [39].

In the less-developed countries' case, like Guinea-Bissau, the supply chain disruptions were felt even more acutely, as they rely more on the imports of finished goods. The companies were highly affected by the pandemic, as these enterprises depend almost entirely on global supply chains. The authors' solutions that concluded the study are to diversify the services and products, that the local companies outsource the usage of metrics that will allow the companies to detect disruptions in early stages, and that more effective management of stock and a proactive attitude in crisis resolution strategies must be implemented [40].

According to the authors, the registered responses during the pandemic from companies in manufacturing and services from Santiago de Cali included changes in demand, absenteeism, and the development of new products. Managers had to address these stimuli by designing and developing new products, putting them into production, distribution, etc. Furthermore, the researchers emphasize the fact that it is really important that managers access all the shared information regarding internal and external stimuli from the supply chain [41].

As the pandemic's disruptions fade little by little, decision-makers must reconsider the idea of redesigning their supply chain network by introducing the newest technology. The use of high tech has its advantages, the main one being the creation of a more resilient supply chain through transparency, security, and traceability [42], a characteristic that

all managers have strived for during the recent turbulent times. But, in order to have a successful transition to Industry 5.0 and for the resilience of the supply chain to increase, a series of strategic measures should be implemented, such as actively involving senior management and receiving financial support and funding from investors and state institutions [43]. According to some researchers [44], the adoption of the 5G mobile technology for the supply chains is mandatory. This technology will have a major impact on supply chain management, as it offers concrete response times and huge data processing and, foremost, links together a massive number of smart devices from anywhere at any given time. That being said, the process is not an easy one by any means, especially in the agro-food business. As such, the paper has revealed a series of challenges that are present in the agro-food supply chain, like technological architecture, security and privacy, big data management, and internet-based infrastructure. The researchers concluded that the identified challenges are quite general, as they represent the entire agro-food sector, and it is possible that each product category will reveal more particular challenges [42].

Since the global supply chain has been negatively impacted by the recent crises (climate change, the pandemic, the Russian–Ukrainian war), logistics networks were likewise affected. The fact that these networks have become more and more complex and integrate more technology (as the transition to Industry 4.0 is almost complete) makes them even more susceptible to disruptions with sometimes catastrophic impacts on the supply chain. As such, according to the research, the authors consider that the integration of logistics collaboration and capacity expansion will have a positive impact on logistics, as the companies would benefit from lower costs, lower CO_2 emissions, and lower accident risks. All these effects will, in the end, create a basis for a more resilient network [45].

Supply chain resilience can be achieved through viability [46], which is the chain's ability to continue functioning through crises. The theory of supply chain viability was based on a seven-pillar approach, such as a viable supply chain design, viable planning and control processes, or digital supply chain and Industry 5.0.

An alternative strategy for interconnected supply chains to adapt to hazards is the conversion strategy [47]. This strategy is generally used to change the supply chain functions in order to better cope with disruptions, just like the COVID-19 pandemic. The authors' conversion is aimed at the production location, production line, storage, usage, distribution channel, and workforce skill set.

Supply chain resilience is a concept frequently used in recent times due to the major crises that the world has been through. Researchers and managers alike are striving to find and implement strategies that will ensure supply chain resilience. According to the authors, one strategy is to adopt blockchain technology, not by itself (as alone, according to the research performed on 603 companies from Egypt, it is sure to have a negative impact on the chain) but rather in conjunction with customer integration or green customer information strategies [48]. Adopting this technology will also help strengthen the decision-making capabilities of global freight management through an industrial blockchain-based global freight decision framework that will incorporate consortium blockchain technology and the Bayesian best–worst method [49].

3. Materials and Methods

The problem we propose to solve is to find an efficient grouping of companies that have as object of activity other activities related to transport, especially those connected with logistics, such as freight forwarding, organization of transport operations on various routes (sea, road, air, or rail), organizing individual or group freight shipments (including pick-up and delivery of goods and shipment grouping), procurement and drafting transport documents and shipping documents (waybills), activities of the customs agents, activities of shipping and air freight forwarders, activities of brokers for space on vessels and aircraft, cargo handling activities involving temporary packing of goods in boxes for the sole purpose of protecting goods during transit, unpacking of boxes, taking samples, and weighing of goods. As a result of the grouping of the companies, we propose to develop

scenarios for making the companies' activities more efficient by implementing specialized software programs and transferring these companies from a lower to a higher group.

The sample studied in the application was chosen from Ilfov County, Romania, because, in terms of logistics services, it is the largest concentrator of input–output resources. Ilfov County, located in a circular position around Bucharest, provides access to utilities (gas, water, electricity) and to the necessary infrastructure specific to the logistics sector (high-speed rail lines to major hubs in Romania and Europe, three motorways, and two international airports to which a cargo airport and access to navigable waterways will be added in the future). The link between Ilfov and Constanta, a port at the Black Sea gateway for goods from east to southeast Europe, is currently traveled by road transportation, facilitated by the A2 Bucharest–Constanta motorway to which access to shipping routes will be added in the future. All these aspects give it an important competitive advantage.

The approach methodology proposed to solve the problem is composed of several stages, including the following:

Stage 1. Selecting the data sample and recording the values of the main indicators in the accounting balance sheets of each company for the year 2020;

Stage 2. Based on the data taken from the account balances, the indicators for evaluating the activity will be calculated for each company;

Stage 3. Apply the cluster analysis for an initial classification of the objects from the sample;

Stage 4. Train a classification neural network with the aim of improving the classification performed in the previous stage and identifying the transfer functions for future use of it;

Stage 5. Develop a scenario using instruments from the digital economy for transferring a company from a particular class to another based on adopting specialized software. Usually, it is considered to be a scenario for transition from a class with low indicator values to a class with higher values.

The data sample consisted of 106 companies from Ilfov County, from a total number of 145, and the first step was to eliminate companies for which it was not possible to calculate the indicators. The initial data for each company are presented in Appendix A.

Our proposed five-step methodology is our own design, and, as far as we know, there are no other studies in the literature that use the same approach to the same dataset. There are, in fact, studies in various fields that use the methods one by one or the same combinations of methods, but there is no study which combines the hidden data results from applying the methods and software that can be used in logistics, such as Odoo ERP (Enterprise Resource Planning). This approach is an important element of the originality of our study.

The indicators that we consider important to capturing the economic–financial situation for each company, calculated on the basis of the data from the balance sheets, are presented in Table 1.

Table 1. The indicators used in the application.

Chr. No.	Coding the Indicator	The Name of the Indicator	The Calculation Formula
1	R1	Economic profitability	(Net profit/Total assets)*100
2	R2	Profit rate	(Gross profit/Turnover)*100
3	R3	Revenue profitability	(Gross profit/Total revenue)*100
4	R4	Capital solvency ratio	(Equity/Total liabilities)*100
5	R5	Overall indebtedness ratio (%)	(Total debts/Total liabilities)*100
6	R6	Inventory ratio	(Inventories/Total Assets)*100
7	R7	Debt ratio	(Debts/Total assets)*100

With a view to calculating the size of the sample of companies to be analyzed, we considered a 95% confidence level (with a corresponding z score of 1.96) and a precision level of ±5% [50]. Given the fact that in this field of activity, a total of 145 SMEs operate in Romania, the sample size was determined by using the following formula [51]:

$$n = \frac{\frac{z^2 \cdot p \cdot (1-p)}{e^2}}{1 + \left[\frac{z^2 \cdot p \cdot (1-p)}{e^2 \cdot N}\right]} = \frac{\frac{1.96^2 \cdot 0.5 \cdot (1-0.5)}{0.05^2}}{1 + \left[\frac{1.96^2 \cdot 0.5 \cdot (1-0.5)}{0.05^2 \cdot 145}\right]} = 106 \quad (1)$$

where N—population size; z—value of z score; e—margin of errors; p—sample proportion.

The algorithm used in the first classification is Ward's hierarchical clustering method, which makes it possible to obtain classes that are as homogeneous as possible and located as far apart as possible from each other. In other words, it tries to maximize the inter-cluster distance and minimize the intra-cluster distance.

For neural network training, we chose the quick prop algorithm, which allows for achieving convergence very quickly compared to the conjugate gradient technique, using both a linear search and the gradient descent technique. Thus, Newton's algorithm is applied to the diagonal of the Hessian matrix, thus performing fewer adjustments. The equations underlying these adjustments are shown below (2)–(4).

$$\delta^{(n)} = -\left(diag\left(H^{(n-1)}\right)\right)^{-1} \cdot g^{(n)} \quad (2)$$

$$w^{(n)} = -\eta^{(n)} \cdot g^{(n)*} + \alpha^{(n)} \cdot w^{(n-1)} \quad (3)$$

$$g^{(n)*} = g^{(n)} + \gamma \cdot w^{(n)} \quad (4)$$

where

- $\delta^{(n)}$ is the iterative step of the nth iteration.
- $g^{(n)}$ is the vector of first-order derivatives of the error function of the weight approximation of the nth iteration.
- $\eta^{(n)}$ is the learning constant at the nth iteration.
- H_n represents the Hessian matrix at the nth iteration.
- $w^{(n)}$ are the weights of the nth iteration.
- $diag\left(H^{(n)}\right)$ is the diagonal from the Hessian matrix using finite difference approximations of second derivatives of the error function with respect to each weight estimate.
- γ is the adjustment factor for weights.

The learning $\alpha^{(n)}$ is computed like in Formula (5).

$$\alpha^{(n)} = \frac{g^{(n)*}}{g^{(n-1)*} - g^{(n)*}} \quad (5)$$

During the execution of the algorithm, the two rates, $\alpha^{(n)}$ and $\eta^{(n)}$, are adjusted according to Formulas (6) and (7).

$$\eta^{(n)} = \begin{cases} \eta_0 \; if \; g^{(n)*} \cdot w^{(n-1)} > 0 \\ \eta_0 \; if \; w^{(n-1)} = 0 \\ 0 \; otherwise \end{cases}, \quad \eta_0 = 0.1 \quad (6)$$

$$\alpha^{(n)} = \begin{cases} \alpha_{max} \; if \; \left|\alpha^{(n)}\right| > \alpha_{max} \\ \alpha_{max} \; if \; \left(g^{(n-1)*} - g^{(n)*}\right) \cdot w^{(n-1)} > 0 \\ \alpha^{(n)} \; otherwise \end{cases}, \quad \alpha^{(n)} = \frac{g^{(n)}}{g^{(n-1)} - g^{(n)}} \quad (7)$$

The quick prop technique uses both the linear search to minimize the error function, which has a polynomial form, and the gradient descent method to restart the search for the minimum error point. When the algorithm has found a minimum point, the weight estimates are considered to be those from the previous step.

4. Results

The data for the computation of the economic indicators (R1–R7 from Table 1) were taken from the balance sheets of the companies, available at the National Tax Administration Agency, for the year 2020. Cluster analysis is used in various areas of human economic activity and involves separating a set of objects according to certain characteristics into homogeneous and distinct classes [52,53]. The first step of our approach was to analyze the data series in terms of the descriptive indicators computed. Therefore, using the Statistical Analysis System (SAS) Enterprise Guide, version 8.3, the following indicators were calculated: the mean, the standard deviation, the skewness, the kurtosis, and the bimodality (Table 2).

Table 2. The descriptive analysis of the data.

Variable	Mean	Std Dev	Skewness	Kurtosis	Bimodality
R1	23.7033	29.8201	0.6241	0.4481	0.3930
R2	18.9349	28.6819	0.9495	1.7056	0.3967
R3	18.3794	28.1358	0.9696	1.8974	0.3892
R4	44.3900	35.5158	−0.4059	−0.5669	0.4621
R5	55.0369	35.9095	0.3995	−0.5874	0.4638
R6	2.0730	6.9488	5.2380	30.9800	0.8347
R7	46.8959	28.5484	0.1189	−0.9972	0.4851

From Table 2, it can be seen that the data set corresponding to indicator R6 is different in the sense that the values of the mean and standard deviation indicators are much lower than those of the other indicators. The value of the skewness indicator provides information about the level of asymmetry in the data series and their approximation of the normal distribution. The skewness indicator follows the same trend in the sense that while the other indicators are close to the normal distribution, the same cannot be said for the R6 indicator. This indicator does not follow the normal distribution. The bolting of a data series is reflected by the calculation of the kurtosis indicator. The value of the kurtosis indicator for the R6 data series is 30.98, which indicates that the shape of the graph of the data series has a very long tail pointing to the right. For the other indicators, the graphs do not show tails pointing excessively to one side or the other, further reinforcing the conclusion provided by the skewness analysis. From the bimodality analysis, we observe that each data series does not show more than one maximum.

If the eigenvalues of the covariance matrix (Table 3) are investigated, information about the level of information provided by the indicators under analysis is obtained. The larger the number of indicators, the more the assumed error is smaller and, therefore, the better the accuracy of the results. From a statistical point of view, the maximum allowed error is 5%, and following the aforementioned approach, only the first three indicators can be kept in the analysis (cumulative = 0.9506). If we increase the number of indicators to six, the level of information lost will be 0.05%, which is statistically satisfactory. When analyzed from an economic point of view, the seven chosen indicators will best reflect the economic situation of a company, so the R7 indicator will be kept in the research.

Table 3. Eigenvalues of the covariance matrix.

	Eigenvalue	Difference	Proportion	Cumulative
1	3904.56457	2820.43302	0.6598	0.6598
2	1084.13155	447.33225	0.1832	0.8430
3	636.79930	398.85241	0.1076	0.9506
4	237.94689	190.86355	0.0402	0.9908
5	47.08334	42.76099	0.0080	0.9988
6	4.32235	1.49457	0.0007	0.9995
7	2.82778		0.0005	1.0000

Then, Ward's algorithm will be applied to make the aggregation graph of the companies in classes with the lowest variance growth within them. Depending on the assumed error level, implicitly, on the place where the dendrogram will be cut, a first classification of the companies can be made.

The aggregation of companies into classes can be seen in Figure 1. Depending on the chosen error level, more or fewer classes can be constructed. For example, if the cut is made at the level of 0.05, we will have four classes which are fairly close to one another. If the graph is cut at the 0.2 level, there will be two non-homogeneous classes. If the 0.1 threshold is chosen, there will be three different classes of enterprises with a homogeneous structure. The structure of each class can be seen in Appendix B.

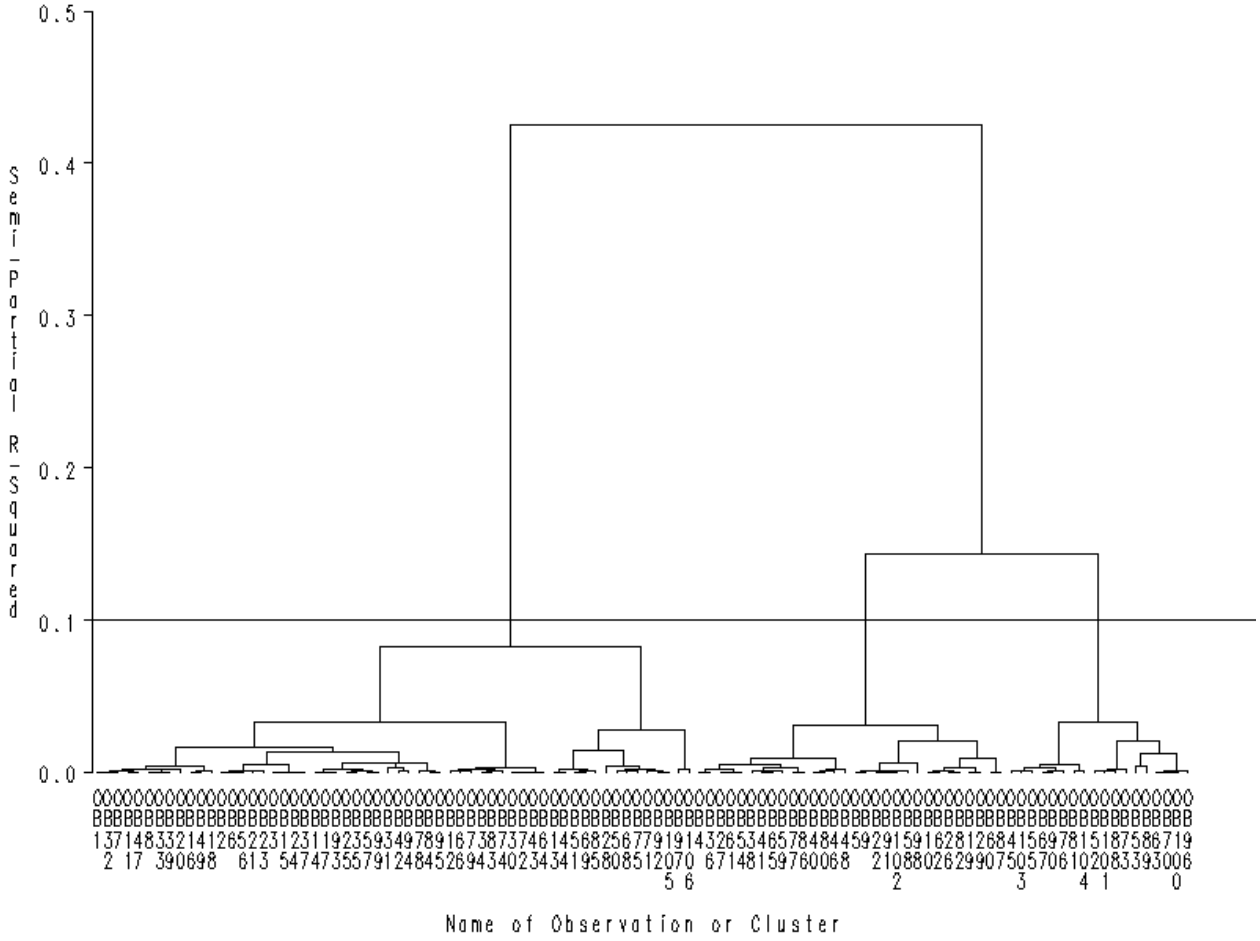

Figure 1. Graph (dendrogram) of companies aggregated in classes.

To this point, a first classification of the companies has been made using cluster analysis. Further on, a neural network classification will be trained in order to improve the previous classification and minimize the error of the classification. The neural network will consist of three layers, namely, the input layer containing the seven neurons, each neuron corresponding to one of the indicators R1–R7; the intermediate layer, which will contain five neurons; and the final layer consisting of three neurons, the classes found in the cluster analysis. The number of neurons in the intermediate layer will be determined experimentally, further keeping the network that will minimize the error.

The neural network training was performed in SAS Enterprise Miner version 15.2; the data sample was divided into 40% network training data, 30% validation data, and 30% testing data. The model chosen was to minimize the mean classification error by maximizing a company's class belonging. The training algorithm was a quick prop, with 100 minimum iterations and 1000 maximum iterations per application cycle.

Before applying the quick prop algorithm on the neural network, the following values of the specific indicators were computed (Figure 2):

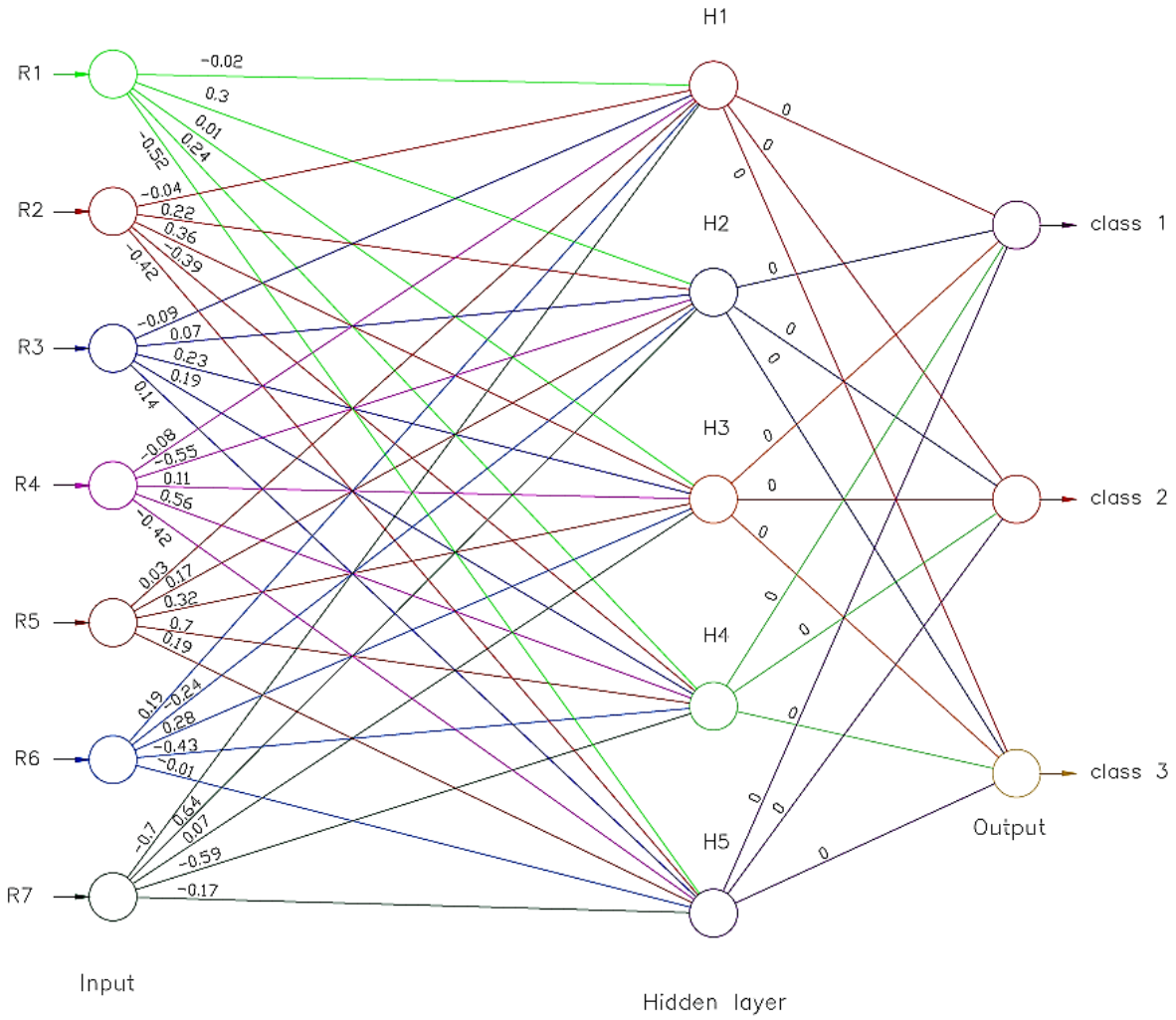

Figure 2. The neural network before training.

- The weights from the input layer to the intermediate layer are as follows:
  - The weights from the indicators to neuron 1 (H1): −0.02, −0.04, −0.09, −0.08, 0.03, 0.19, −0.57;
  - The weights from the indicators to neuron 2 (H2): 0.30, 0.22, 0.07, −0.55, 0.17, −0.24, and 0.64;
  - The weights from the indicators to neuron 3 (H3): 0.01, 0.36, 0.23, 0.11, 0.32, 0.28, and 0.07;
  - The weights from the indicators to neuron 4 (H4): 0.24, −0.39, 0.19, 0.56, 0.70, −0.43, and −0.59;
  - The weights from the indicators to neuron 5 (H5): −0.52, −0.42, 0.14, −0.42, 0.19, −0.01, and −0.17;
- The weights from the intermediate layer to the final layer are initially zero.
- The activation thresholds (BIAS) of the neurons in each layer are as follows:
  - For the intermediate layer: −0.77, −0.79, −0.52, −0.52, −0.55;
  - For the final layer: −0.39, −0.49, −1.30.
- The objective function value is 0.3098.

The training of the neural network required 321 iterations to reach the expected result, and the evolution of the average training and validation errors are shown in Figure 3.

From the graph of the two errors, it can be seen that at the beginning, both errors had quite important fluctuations, but starting with iteration 95, they start to stabilize and tend towards zero. The level of the error decreased from 0.3098 to 0.002.

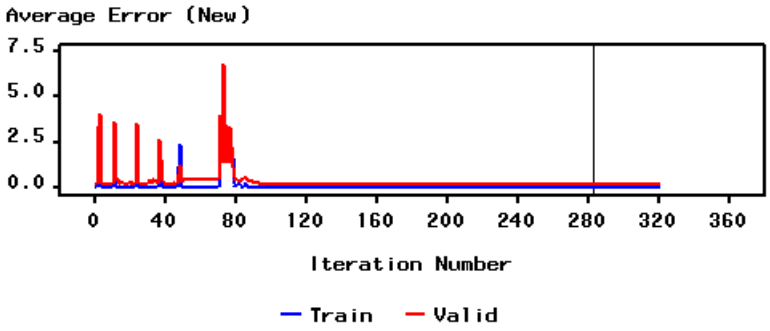

Figure 3. The evolution of average training and validation errors of the neural network.

After the neural network was successfully trained, the following values of specific indicators were registered (Figure 4):

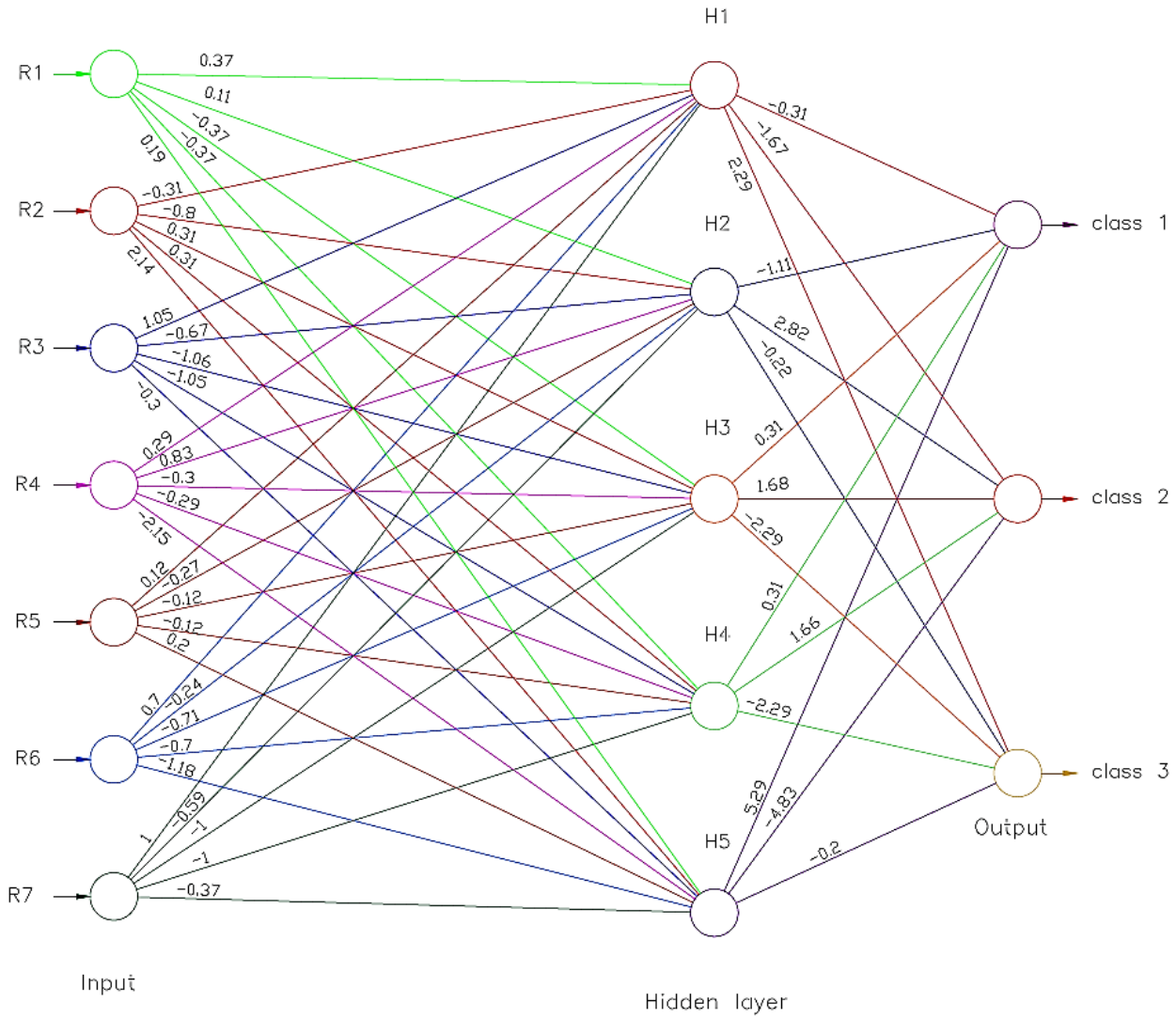

Figure 4. The neural network after passing through the training process.

- The weights from the input layer to the intermediate layer are as follows:

- The weights from the indicators to neuron 1 (H1): 0.37, −0.31, 1.05, 0.29, 0.12, 0.70, and 1.00;
- The weights from the indicators to neuron 2 (H2): 0.11, −0.80, −0.67, 0.83, −0.27, −0.24, and −0.59;
- The weights from the indicators to neuron 3 (H3): −0.37, 0.31, −1.06, −0.30, −0.12, −0.71, −1.00;
- The weights from the indicators to neuron 4 (H4): −0.37, 0.31, −1.05, −0.29, −0.12, −0.70, and −1.00;
- The weights from the indicators to neuron 5 (H5): 0.19, 2.14, −0.30, −2.15, 0.20, −1.18, and −0.37;

- The weights from the intermediate layer to the final layer are as follows: −0.31, −1.11, 0.31, 0.31, 5.29 (for class 1), −1.67, 2.82, 1.68, 1.66, −4.83 (for class 2), 2.29, −0.22, −2.29, −2.29, −0.20 (for class 3);
- The activation thresholds (BIAS) of the neurons in each layer are as follows:
  - For the intermediate layer: −1.66, −1.01, 1.66, 1.65, −0.85;
  - For the final layer: −1.21, −3.01, −0.75.
- The objective function value is 0.002.

For the future application of the neural network presented above, the transfer functions are as follows:

- For the hidden layer of neurons, Equations (8)–(12) are as follows:

$$H1 = 0.37*R1 + -0.31*R2 + 1.05*R3 + 0.29*R4 + 0.12*R5 + 0.7*R6 + 1*R7; H1 = -1.66 + H1; \quad (8)$$

$$H2 = -0.11*R1 - 0.8*R2 - 0.67*R3 + 0.83*R4 - 0.27*R5 - 0.24*R6 - 0.59*R7; H2 = -1.01 + H2; \quad (9)$$

$$H3 = -0.37*R1 + 0.31*R2 - 1.06*R3 - 0.3*R4 - 0.12*R5 - 0.71*R6 - 1*R7; H3 = 1.66 + H3; \quad (10)$$

$$H4 = -0.37*R1 + 0.31*R2 - 1.05*R3 - 0.29*R4 - 0.12*R5 - 0.7*R6 - 1*R7; H4 = 1.65 + H4; \quad (11)$$

$$H5 = 0.19*R1 + 2.14*R2 - 0.3*R3 - 2.15*R4 + 0.2*R5 - 1.18*R6 - 0.37*R7; H5 = -0.85 + H5; \quad (12)$$

- For the final layer of neurons, Equations (13)–(15) are as follows:

$$P\_class\_1 = -0.31*H1 - 1.11*H2 + 0.31*H3 + 0.31*H4 + 5.29*H5; P\_class\_1 = -1.21 + P\_class\_1; \quad (13)$$

$$P\_class\_2 = -1.67*H1 + 2.82*H2 + 1.68*H3 + 1.66*H4 - 4.83*H5; P\_class\_2 = -3.01 + P\_class\_2; \quad (14)$$

$$P\_class\_3 = 2.29*H1 - 0.22*H2 - 2.29*H3 - 2.29*H4 - 0.2*H5; P\_class\_3 = -0.75 + P\_class\_3; \quad (15)$$

5. Discussion

After the training of the neural network, the classes changed their structure, as follows: the company Top Wash 331 SRL moved from class 2 to class 3, and the companies Air Sea Forwarders SRL and Time Critical Line SRL moved from class 1 to class 2. The complete structure of the classes can be seen in Appendix B.

A comparative analysis of the average of each indicator at the level of each group (Table 4) shows that class 1 contains enterprises with a low economic or financial situation,

class 2 contains enterprises with a good situation, and class 3 is composed of enterprises with relatively high values of the indicators, so it will be the class of profitable companies.

Table 4. The average of every indicator for each class for the year 2020.

Class	R1	R2	R3	R4	R5	R6	R7
Class 1	10.09	5.21	5.09	16.73	82.98	2.48	57.42
Class 2	21.05	14.46	14	70.55	28.97	0.3	38.87
Class 3	68.15	66.68	64.69	83.24	15.2	3.78	28.98

Class 1 includes companies that, although at first appearance seem large in terms of turnover, if their economic situation is examined as a whole, they are unprofitable. Thus, these enterprises have an average stock of 135,400 RON, with advance expenses of 146,516 RON and higher debts. In comparison with the other classes, despite the fact that the revenues for an accounting year are high on average, more than 22 million RON, the expenses have the same trend, and the gross profit is also at a low level. The management policy of these companies is mainly based on a debt-based approach, so the amount of debt is more than 6.2% higher than the level of receivables, and the advance expenses are the highest compared to the other classes. At first sight, the managerial decision-making in these companies would be an investment in reorganization, modernization, and digitization, but a closer look at the value of all indicators as a whole, in particular the high number of employees on average, would indicate the opposite. These companies have a policy of preserving activity and maintaining profit margins.

The second class is made of companies with an average situation, such as the following: the value of stocks is 37,897 RON, and the average advance expenses are 20,598 RON. The ratio between the income and the expenses is 13.66%, and the ratio between the receivables and the debts is 0.31%; this indicates that the profit margin is higher, on average, than the one of the first cluster, and the debts will be covered by the future amounts which will be collected from the customers. Also, the average stock level is 37,897 RON, which is 3.6 times lower than in the first group, and this indicates that no additional logistics costs will be generated.

Class 3 is composed of companies that have seen an opportunity in the COVID-19 crisis, and they have reorganized their activity in order to respond promptly to the customers' expectations. As a result, on average, revenues are 1.63 times higher than expenses, prepaid expenses are the lowest, stocks are 3.69 times lower than in class 2 and 13.18 times lower than in class 1, and the receivables are 22.7% higher than the debts. Also, the current assets are the smallest, on average, compared to the other classes.

Up to this point, in accordance with the proposed methodology, as far as the analysis is concerned, we have performed the classification of the companies into classes differentiated on the basis of the evolution of the main indicators because the awareness of the real position in the specialized market is the first step in operational reconfiguration. Moreover, depending on the available resources, the maximum level of logistic and informational modernization that can be achieved may be preset.

In the pages to follow, we present the evolution, during the three years of the pandemic (2020–2022), of the average indicators for each class. From Table 5, it can be seen that, within each class, the average indicator does not change much from one year to another. If we look at the three classes in comparison, we can assert that the most stable class is the second class, with the average for each indicator varying very little compared to the other classes (Figure 5). As it is well known throughout the business world, from one year to another, some firms change their activity or disappear. From the class of companies with a good financial situation, only one company was liquidated, probably for non-financial reasons. From the second class, no company has suffered, nor have they changed their object of activity or been dissolved. As for the third class, the financially precarious companies, three companies have dissolved year-by-year, which indicates that, although the logistics sector

has benefited during the pandemic, the decisions and strategies taken by managers have led to their bankruptcy.

Table 5. Changes in class average for each indicator between 2020 and 2022.

Class	Year	R1	R2	R3	R4	R5	R6	R7
class 1	2020	10.09	5.21	5.09	16.73	82.98	2.48	57.42
	2021	14.79	2.68	10.81	20.53	79.05	2.46	59.31
	2022	17.9	3.73	2.82	26.9	72.74	1.88	57.16
class 2	2020	21.05	14.46	14	70.55	28.97	0.3	38.87
	2021	37.32	13.18	13.03	64.9	34.42	0.19	46.31
	2022	26.99	13.01	11.5	63.86	35.59	0.29	50.08
class 3	2020	68.15	66.68	64.69	83.24	15.2	3.78	28.98
	2021	54.42	62.67	101.92	85.46	14.54	3.18	30.24
	2022	56.73	52.82	52.18	75.49	24.45	2.53	41.67

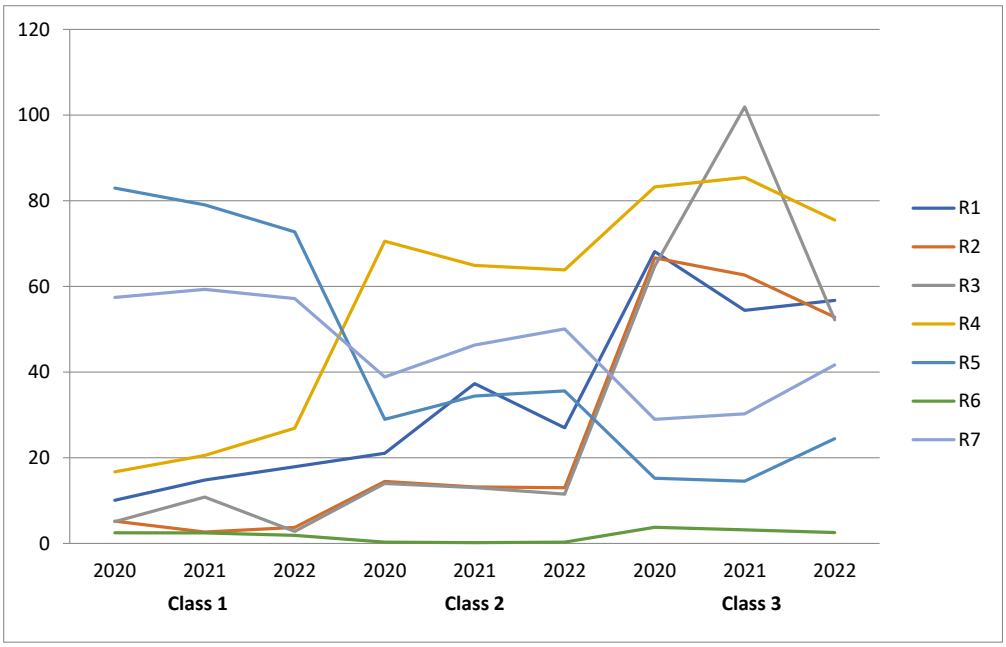

Figure 5. The graph of the values of each indicator for each class between 2020 and 2022.

Further on, we will consider IB Cargo SRL as a company belonging to class 2 (Table 6), and we will propose a scenario to improve its financial indicators and move it into the class of companies that have adapted to the health crisis, adopted a customer-centered policy, and embraced digitalization.

Table 6. The average indicators for class 2, year 2022, and IB Cargo SRL.

	R1	R2	R3	R4	R5	R6	R7
Class 2	26.99	13.01	11.5	63.86	35.59	0.29	50.08
IB Cargo SRL	26.03	6.74	6.64	29.27	66.67	0.08	87.12

To streamline the stock records in the warehouses of IB Cargo SRL, we chose the ERP program Odoo (On-Demand Open Object) [54,55]. Although previously known as TinyERP or OpenERP, Odoo, version 15.0 is an open-source software. It allows the implementation of new features and programs to better meet the information needs of SMEs [56]. The warehouse module of this program keeps track of the stocks in the warehouses owned by the company, as well as the incoming and outgoing products (Figure 6).

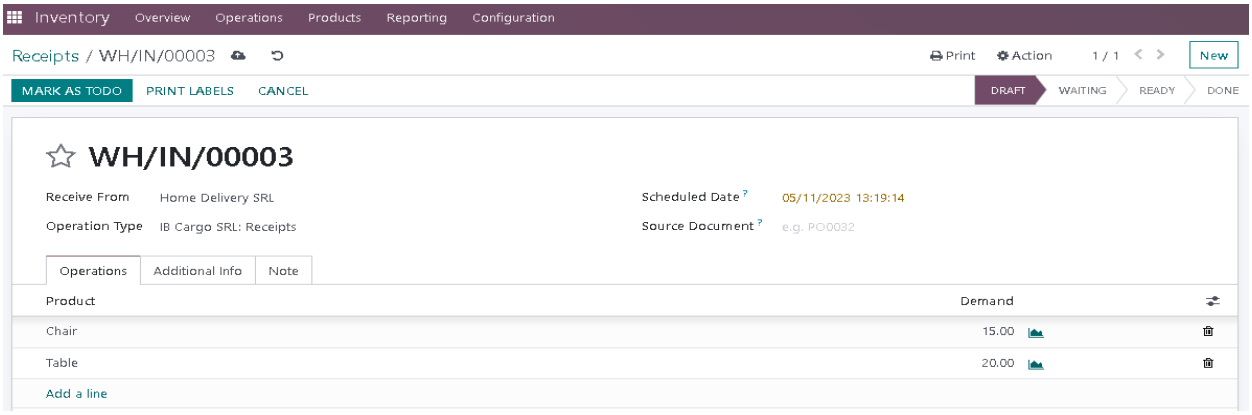

Figure 6. Incoming and outgoing warehouse via Odoo ERP.

An incoming document can have different stages: draft, waiting, ready, or done. A document in the draft mode assumes that it has not been confirmed yet; the reservation of the products has not been made. If, from the draft mode, it goes into the waiting mode, this requires several things: either waiting for an additional operation to be completed or waiting for the products to arrive in stock. If the status is selected as ready by pressing the validate button in the bar below the menu, then the transfer is ready to be processed, and the document has to go into the done mode to be completed.

For each product, if it enters the warehouse for the first time and there is no information about it in the database, it is filled in manually. This will require information such as the full name, price, production cost, and storage dimensions (weight, volume, available quantity). If the product is available, the request is directly transferred to the ready or done mode (by pressing the validate button). For each product, a label is generated with the bar codes, as well as the shipping document.

The outgoing and return operations from the warehouse have, in general, the same operations as the incoming ones, where the operator has the same stages of passing a document: draft, waiting, ready, done. With Odoo ERP, the Inventory module, at any time, the business user can have an overview of the inputs, outputs, and returns to/from the warehouse. Furthermore, if there are requests to be completed, they can be viewed in the Inventory Overview section (Figure 7).

Moves History

Done ×

Filters | Group By | Favorites | 1-14 / 14

Date	Reference	Product	From	To	Quantity	Status
05/27/2023 21:27:02	WH/RET/00003	Alphabet Toys	Partners/Vendors	WH/Stock	5.00	Done
05/27/2023 21:22:51	WH/RET/00002	Table	Partners/Vendors	WH/Stock	44.00	Done
05/27/2023 21:07:10	WH/RET/00001	Chair	Partners/Vendors	WH/Stock	10.00	Done
05/27/2023 21:01:16	WH/IN/00003	Air Filter	Partners/Vendors	WH/Stock	15.00	Done
05/27/2023 21:00:49	Product Quantity Updated	Air Filter	Virtual Locations/Inventory adjustment	WH/Stock	20.00	Done
05/27/2023 20:57:23	WH/OUT/00002	Table	WH/Stock	Partners/Vendors	20.00	Done
05/27/2023 20:57:23	WH/OUT/00002	Chair	WH/Stock	Partners/Vendors	15.00	Done
05/27/2023 20:55:31	WH/IN/00002	Alphabet Toys	Partners/Vendors	WH/Stock	20.00	Done
05/27/2023 20:55:12	Product Quantity Updated	Alphabet Toys	Virtual Locations/Inventory adjustment	WH/Stock	300.00	Done
05/27/2023 20:50:49	WH/OUT/00001	Chair	WH/Stock	Partners/Customers	200.00	Done
05/27/2023 20:33:27	WH/IN/00001	Table	Partners/Vendors	WH/Stock	20.00	Done
05/27/2023 20:33:27	WH/IN/00001	Chair	Partners/Vendors	WH/Stock	15.00	Done
05/27/2023 20:29:11	Product Quantity Updated	Chair	Virtual Locations/Inventory adjustment	WH/Stock	1,500.00	Done
05/27/2023 20:27:58	Product Quantity Updated	Table	Virtual Locations/Inventory adjustment	WH/Stock	2,000.00	Done

Figure 7. Moves history from the warehouse at a certain moment.

If someone wants to see the actual stock in the warehouse from the Reporting menu, the Stock section of Odoo ERP offers this possibility. Also, for each product, it is possible to view the history of stock placements/issues in the warehouse, all the replacements of the products, and a forecast based on the history. Based on the manually added quantities, receipts, and issues, a forecast of the future stock can be made.

In the dashboard section, there is aggregated information about the inventory flow (Figure 8), such as products being grouped according to the total quantity traded (total quantity inbound–outbound per product), total quantity traded for each partner (supplier or customer), total quantity in each warehouse (if more than one), and total quantity traded for each warehouse location. Furthermore, for each category, products, partners, warehouses, locations, and the total number of transactions (moves) made are displayed.

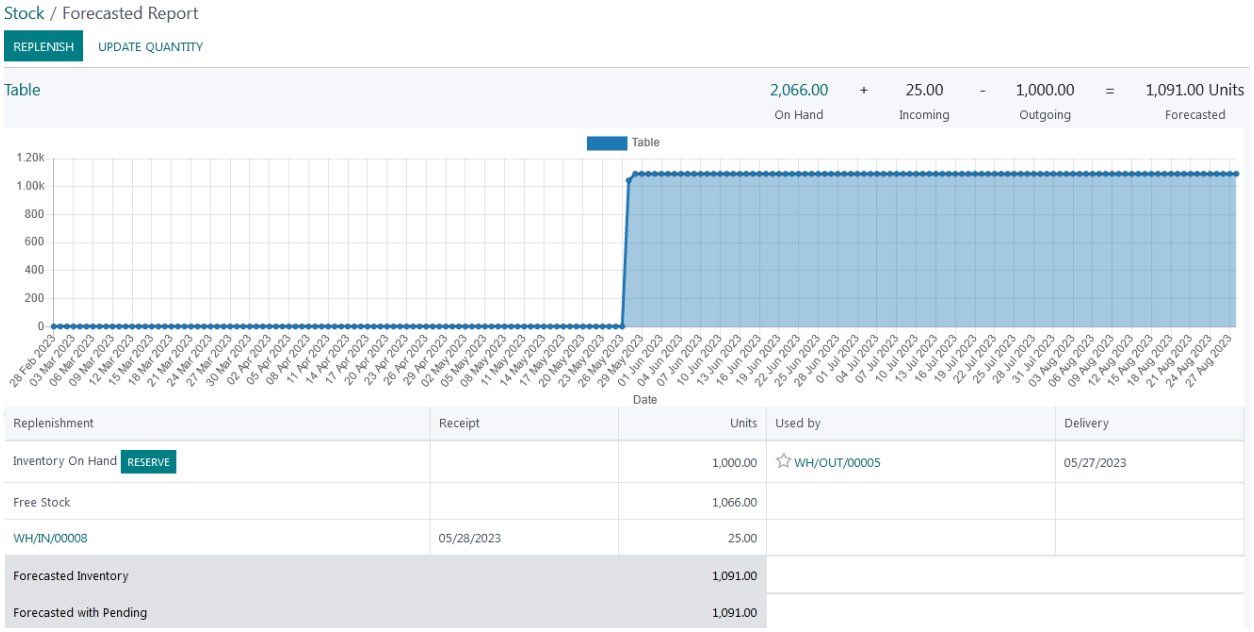

Figure 8. Inventory flow.

The implementation of an ERP program in a company must not be performed all at once but rather in stages, each stage having a certain time for implementation and validation. Moreover, once the decision to adopt an ERP product has been made, this involves additional costs related to the purchase, the maintenance, the software development, the staff training, and the re-organization of the whole business. The results of ERP product adoption are not seen immediately but over time, usually within 2–3 years of implementation. Once the staff is familiar with the software and all the company's activities are supported by it, it can be observed that by automating certain processes specific to Industry 4.0, the flow and processing time of requests will be optimized, costs will be reduced, and, in economic terms, efficiency will increase. Choosing an ERP product is very important, especially in today's post-crisis economic conditions. If, during the COVID-19 pandemic, the need for the digitization of companies increased substantially, then with the reduction in interpersonal distance and the return to business as usual, companies have maintained their level of digitization. From an Industry 4.0 point of view, an ERP product has to be flexible to respond to the immediate information needs of companies and, moreover, to be accessible from anywhere, anytime, and from different devices. The current trend in the supply chain, in the post-COVID-19 era, is to use predominantly SaaS (Software as a Service) ERP software, i.e., software that can be accessed via an internet browser from any device connected to the internet. In this way, the team is no longer required to be physically present in a particular location but can work and communicate efficiently from anywhere in the world.

Our proposed model can be applied in the logistics sector in any region. The results we found provide an overview of the logistics sector in southeast Romania. It is well known that Ilfov concentrates most of the warehouses serving Romania and has the most developed infrastructure in the country, with three highways that ensure fast transfer between warehouses, both inbound and outbound. The classification model of the companies proposed by us can be very useful both from the perspective of development strategies and from the perspective of attracting capital/investment from the country or from abroad. As a result, for potential investors, the model can facilitate the decision-making process. From these considerations, we can conclude that the results found by us can be extrapolated to the whole country or on a regional level.

6. Conclusions

In the research paper, we used advanced classification techniques and elements of artificial intelligence to classify firms engaged in logistics-related activities into three distinct classes based on various indicators. Additionally, the authors proposed specialized software implementation for firms in a lower class to improve their activity and move them to a higher class. The program would involve introducing digitalization to enhance efficiency and improve indicators over the study period. The results suggest that by using this software, firms can potentially enhance their financial accounting performance and transition to a higher performance class.

Regarding Q1, three clusters of companies were found in the County of Ilfov. The managers of the high-performing class of companies saw an opportunity for development at the time of the downturn of the COVID-19 crisis and made massive investments towards efficient logistics programs, while firms in classes 2 and 3 were more conservative, with managers mainly focusing on profit margins and not having a medium- and long-term vision.

Q2 was answered by proposing the introduction of high-performance and specialized logistics software to improve financial indicators in the coming financial years. Thus, only one recovery scenario was proposed for companies in a lower class, namely, to adopt real-time, adaptive software that can be accessed on multiple devices. The methodology used in the article, the employment of deep data mining and artificial intelligence techniques combined with the specific Industry 4.0 process automation software proposal, are innovative elements of the research paper.

Although we met all of the research objectives, the authors identified that this study has several limitations. First, the study is conducted on SMEs in Ilfov County, which does not allow the extension of the conclusions in the field of logistics to the whole of Romania. Secondly, the quantitative method used, although it is appropriate and has generated considerable results, can be improved by using other approaches in the area of evolutionary methods. Thus, in order to further refine the classification, the neural network constructed using genetic algorithms can be trained. Another limitation is related to data availability. The study was conducted only for the years 2020–2022, but with the end of the pandemic and the gradual return of humankind to life as it was before, we can anticipate that logistics activity will follow a slightly downward trend. This needs to be investigated in a future paper, following the evolution of the business activity trend over time. Other directions for future research can be the extension of the study to the whole country so as to avoid errors by studying a representative County, the synchronization of the conclusions found at the European level, and the analysis, over time, of the evolution of the logistics sector in Romania.

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Appendix A

Table A1. The Initial Values of the Sample Data Indicators for 2020.

Company	R1	R2	R3	R4	R5	R6	R7
DHL Logistics SRL	31.65	10.01	9.25	57.72	42.28	0	47.19
Karl Heinz Dietrich International Exped SRL	5.3	24.95	16.42	92.58	7.42	0.23	5.67
Dietrich-Honhold Logistics SRL	10.5	21.36	21.03	94.63	5.37	0.08	4.4
Rail Cargo Logistics-Romania Solutions SRL	0.22	1.26	1.25	63.85	21.3	0.01	49.95
Egetra Romania SA	−7.57	−8.3	−8.27	79.82	20.18	0.03	20.17
ATR Services SRL	15.54	22.74	21.91	86.05	13.95	0	11.64
Forest Trans International SRL	9.19	6.94	6.83	60.58	39.42	0.77	47.51
EOPS Solutions SRL	34.69	22.3	22.15	50.84	49.16	0.76	23.93
Merchant Global Solution SRL	2.87	2.66	2.54	73	27	0.03	13.46
Cargo Delivery SRL	33.9	20.73	20.29	57.57	42.43	0.34	39.81
Cargo Service Italia SRL	37.28	25.28	25.03	72.16	27.84	0.01	64.69
AMEX Logistic SRL	55.62	16.66	16.63	55.66	44.34	0.46	74.72
Elitte Logistic & Forwarding SRL	16.43	14.91	14.87	72.51	27.49	0	56.84
Logisterra Line SRL	64.49	12.23	12.23	64.88	35.12	0	74.77
TC Crown Logistics SRL	80.33	17.05	16.73	79.56	20.44	0	55.34
Eurointertrans Personal Services SRL	26.31	22.19	21.99	45.05	54.95	0	19.71
Sonico Expert SRL	25.94	28.37	28.17	94.78	5.22	2.71	18.1
DCM Spedition SRL	23.61	15.41	15.41	86.5	13.5	0	49.46
FENI International SRL	−42.13	−9.72	−9.65	85.79	14.21	0	34.78
Theocrys Trans-Construct SRL	41.22	25.93	25.96	48.77	51.23	1.11	18.76
Logikair Cargo SRL	2.83	1.87	1.86	77.93	22.07	0	42.08
Kiparom Grup SRL	25.82	22.5	22.3	69.15	30.85	0	44.69
CDC Logistic Transport SRL	32	30.55	30.55	73.03	26.97	0	19.82
Quick Expeditii SRL	53.54	22.22	22.22	53.67	46.33	2.06	66.38
Freight Express Intersped SRL	10.86	12.66	11.91	61.74	38.26	0	50.26
ACN Transport SRL	38.3	29.57	29.57	74	26	0	29.55
Exped Cargo Company SRL	−53.61	−22.15	−21.83	81.14	18.86	0	31.05
Euro Trans Logistics SRL	17.56	15.7	14.95	80.86	19.14	0	17.97
Top Wash 331 SRL	16.49	50.83	50.83	87.19	12.81	51.85	3.92
Georginor Eurotrans SRL	24.01	26.04	26.04	81.64	18.36	0.47	22.76
DSV Solutions SRL	10.62	4.29	4.23	27.23	71.74	0.01	82.52
Yusen Logistics (Romania) SRL	3.42	1.43	1.42	35.27	63.26	0.37	70.54
IB Cargo SRL	17.74	5.97	5.9	46.63	48.65	0.03	76.88
SLS Cargo SRL	0.15	0.05	0.05	26.74	73.26	3.12	71.61
Rohel Trans International SRL	2.25	0.89	0.88	30.28	69.72	0.45	85.59
A&C Trans Company International SRL	13.26	5.32	5.28	16.74	82.88	0.01	59.48
Hellmann Worldwide Logistics SRL	21.26	7.46	7.28	23.39	76.61	4.43	89.65
ASG Wind Transport SRL	20.01	11.54	11.01	33.43	66.57	20.34	30.79
Cardoil Logistic SRL	−11	−9.52	−9.5	−13.6	113.6	1.51	36.28
Oepia SRL	18	2.28	2.27	32.58	67.42	2.88	42.92
Air Sea Forwarders SRL	17.8	5.31	5.23	52.66	47.31	0.08	71.61
Unimasters Logistics SRL	−2.48	−0.64	−0.63	−3.88	103.88	2.29	87.72
AS World Cargo SRL	25.45	5.01	4.9	25.46	74.54	0	52.41
Serim Prestari Servicii SRL	6.68	2.32	2.3	15.74	84.25	1.1	120.61

Table A1. *Cont.*

Company	R1	R2	R3	R4	R5	R6	R7
Complete Cargo SRL	41.92	5.53	5.5	8.03	91.97	0	81.67
Pegasus Supply-Chain Solutions SRL	1.29	1	0.97	48.37	51.63	0	49.01
Carpathis Trans SRL	2.71	0.6	0.6	38.17	61.83	19.49	53.79
Time Critical Line SRL	17.91	10.97	10.33	58.95	41.05	0.22	77.78
Bog Eficient Transcom SRL	23.13	18.44	18.12	35.52	64.48	3.55	58.09
Mutu Trans International SRL	31.38	20.36	20.22	−36.22	136.22	16.86	60.16
Unit Logistics Services SRL	2.8	7.16	6.89	42.44	57.56	0.45	13.63
Global Fast Logistic SRL	15.72	5.01	4.52	15.89	84.11	36.91	40.73
DM Expres 4 You SRL	6.56	3.47	3.34	22.75	77.25	0	83.49
ABC World Logistic SRL	17.65	6.61	6.6	17.77	82.23	0.01	61.58
Gatt SRL	8.73	20.54	19.85	22.8	77.2	0	10.68
Oansibo Safetytrans SRL	38.61	12.66	12.63	38.7	61.3	0	57.1
Sky Courier SRL	11.83	6	5.95	62.64	37.36	0	79.47
Rogrialtrans Spedition SRL	1.73	1.68	1.68	10.19	89.81	0	59.45
Trans Conect SRL	15.95	34.06	31.94	15.98	84.02	0.59	54.21
Link Global Logistic Transport SRL	8.61	6.61	6.57	36.56	63.44	0.05	15.28
International Romexpress Service LTD SRL	−27.15	−13.74	−13.57	−8.48	108.48	0.49	39.97
Theo Smart Logistic SRL	9.99	3.65	3.64	13.51	86.49	0.91	80.45
Ideal Business Group SRL	−5.85	−3.2	−3.2	9.41	90.59	3.13	96.06
Elitte World Transport SRL	13.23	6.91	6.9	−23.76	123.76	0	62.88
DIL Best Consulting&Services SRL	−1.74	−1.35	−1.2	−2.02	102.02	0.11	20.76
Continental Logistics SRL	−3.89	−1.72	−1.71	29.61	69.71	0.11	64.74
Marun Spedition SRL	39.33	17.15	17.15	37.09	62.91	0	76.89
Express Clearance Consult SRL	3.66	1.68	1.68	32.15	67.85	0.12	18.83
Hiro Logistics Solutions SRL	36.44	12.58	12.57	26.13	65.84	0	34.44
Hartmann Logistik SRL	−5.59	0.06	0.06	−19.07	119.07	1.13	87.42
Ferrovia Container SRL	3.11	4.44	4.44	0.49	99.51	0	7.78
Terratrans Speditions SRL	−17	−7.2	−6.21	−37.52	137.52	0	84.93
Muveo Solutions SRL	3.1	5.15	5.14	39.39	60.61	4.94	14.56
Teen Logistics Services SRL	7.06	24.71	23.79	37.66	62.34	0.52	15.84
Meihang Transport SRL	−4.47	−13.31	−12.78	−20.29	120.29	0.34	62.27
Swiss Yrene SRL	28.11	49.87	49.22	30.13	69.87	11.39	71.29
Westwind International SRL	28.55	23.69	23.51	28.67	71.33	0	19.29
Trans Logistic Enterprise SRL	12.17	14.56	14.26	13.83	86.17	0	17.13
Air Logistic Service SRL	27.13	35	34.9	27.19	72.81	0	77.97
Hazzara Asset Spedition'91 SRL	0.55	1.2	1.2	0.76	99.24	0.98	36.73
Veslam Shipping and Forwarding SRL	−10.22	−2.84	−2.84	−35.61	135.61	0	59.7
Transgroup Global SRL	30.65	6.01	6.01	31.3	68.7	0	47.98
Dav Truck & Trailer SRL	16.92	22.72	22.72	−3.11	103.11	0	37.89
Smart Dinamic Concept SRL	30.53	31.37	31.37	31.21	68.79	0	75.39
Nairda Spedition SRL	−20.35	−64.39	−64.38	29.44	70.56	0	85.56
Kalia Spedition SRL	27.47	14.46	13.36	27.08	72.92	0	70.48
Imperial Trend Universal SRL	−8.22	−15.14	−15.14	−41.02	141.02	0	64.21
Steelex SRL	−2.22	−46.53	−46.53	6.9	93.1	0	98.8
Unit Cargo Transport Intelligence SRL	81.63	39.18	39.1	83.54	16.46	0.26	1.91
RO Freight Forwarders SRL	76.48	81.08	79.26	76.5	23.5	0	86.03
Shift Spedition SRL	40.29	80.51	80.21	40.48	59.52	0	45.34
New Tactic ALS SRL	69.07	15.53	15.43	87.61	12.39	1.42	17.88
AS World Fastfreight SRL	74.81	92.78	92.78	92.57	7.43	0	6.1
Professional Border Services SRL	63.15	41.58	41.58	83.99	16.01	0	43.06
Levon Logistics SRL	93.29	93.04	93.04	93.34	6.66	0	6.16
Avalon Logistic SRL	98.84	93.38	93.1	98.89	1.11	0	70.17
Global Star Transport SRL	62.15	46.28	46.28	71.79	28.21	0.61	23.5
Selecris Logistic SRL	95.25	65.22	65.22	93.76	6.24	0.05	10.35
Alpenlog Solutions SRL	77.08	98.43	98.03	77.16	22.84	0	77.06
Logistic Option SRL	15.86	85.3	72.06	70.75	29.25	0	0.18
Ando Trans Divers SRL	66.98	45.65	45.65	86.31	13.69	0.25	25.49
Cogen Transport Logistic SRL	55.16	89.49	89.49	86.91	8.87	0	9
Dispo Serv Europe SRL	90.6	83.57	83.56	90.83	9.17	0	2.74
Util Serv & Logistic SRL	64.43	77.72	77.72	88.65	11.35	0.05	95.74
Alean Partners SRL	56.33	32.27	31.07	73.12	1.55	7.36	1.28
Euroborder Euroasia Security SRL	96.97	55.14	34.78	98.21	1.79	9.9	24.63

Appendix B

Table A2. The Structure of the Classes Resulting from Cluster Analysis and Neural Network Training.

Class	Cluster Analysis	Neural Network Analysis
Class 1	DSV Solutions SRL, Yusen Logistics (Romania) SRL, IB Cargo SRL, SLS Cargo SRL, Rohel Trans International SRL, A&C Trans Company International SRL, Hellmann Worldwide Logistics SRL, ASG Wind Transport SRL, Cardoil Logistic SRL, Oepia SRL, Air Sea Forwarders SRL, Unimasters Logistics SRL, AS World Cargo SRL, Serim Prestari Servicii SRL, Complete Cargo SRL, Pegasus Supply-Chain Solutions SRL, Carpathis Trans SRL, Time Critical Line SRL, Bog Eficient Transcom SRL, Mutu Trans International SRL, Unit Logistics Services SRL, Global Fast Logistic SRL, DM Expres 4 You SRL, ABC World Logistic SRL, Gatt SRL, Oansibo Safetytrans SRL, Sky Courier SRL, Rogrialtrans Spedition SRL, Trans Conect SRL, Link Global Logistic Transport SRL, International Romexpress Service LTD SRL, Theo Smart Logistic SRL, Ideal Business Group SRL, Elitte World Transport SRL, DIL Best Consulting&Services SRL, Continental Logistics SRL, Marun Spedition SRL, Express Clearance Consult SRL, Hiro Logistics Solutions SRL, Hartmann Logistik SRL, Ferrovia Container SRL, Terratrans Speditions SRL, Muveo Solutions SRL, Teen Logistics Services SRL, Meihang Transport SRL, Swiss Yrene SRL, Westwind International SRL, Trans Logistic Enterprise SRL, Air Logistic Service SRL, Hazzara Asset Spedition'91 SRL, Veslam Shipping and Forwarding SRL, Transgroup Global SRL, Dav Truck&Trailer SRL, Smart Dinamic Concept SRL, Nairda Spedition SRL, Kalia Spedition SRL, Imperial Trend Universal SRL, Steelex SRL	DSV Solutions SRL, Yusen Logistics (Romania) SRL, IB Cargo SRL, SLS Cargo SRL, Rohel Trans International SRL, A&C Trans Company International SRL, Hellmann Worldwide Logistics SRL, ASG Wind Transport SRL, Cardoil Logistic SRL, Oepia SRL, Unimasters Logistics SRL, AS World Cargo SRL, Serim Prestari Servicii SRL, Complete Cargo SRL, Pegasus Supply-Chain Solutions SRL, Carpathis Trans SRL, Bog Eficient Transcom SRL, Mutu Trans International SRL, Unit Logistics Services SRL, Global Fast Logistic SRL, DM Expres 4 You SRL, ABC World Logistic SRL, Gatt SRL, Oansibo Safetytrans SRL, Sky Courier SRL, Rogrialtrans Spedition SRL, Trans Conect SRL, Link Global Logistic Transport SRL, International Romexpress Service LTD SRL, Theo Smart Logistic SRL, Ideal Business Group SRL, Elitte World Transport SRL, DIL Best Consulting&Services SRL, Continental Logistics SRL, Marun Spedition SRL, Express Clearance Consult SRL, Hiro Logistics Solutions SRL, Hartmann Logistik SRL, Ferrovia Container SRL, Terratrans Speditions SRL, Muveo Solutions SRL, Teen Logistics Services SRL, Meihang Transport SRL, Swiss Yrene SRL, Westwind International SRL, Trans Logistic Enterprise SRL, Air Logistic Service SRL, Hazzara Asset Spedition'91 SRL, Veslam Shipping and Forwarding SRL, Transgroup Global SRL, Dav Truck&Trailer SRL, Smart Dinamic Concept SRL, Nairda Spedition SRL, Kalia Spedition SRL, Imperial Trend Universal SRL, Steelex SRL
Class 2	DHL Logistics SRL, Karl Heinz Dietrich International Exped SRL, Dietrich-Honhold Logistics SRL, Rail Cargo Logistics-Romania Solutions SRL, Egetra Romania SA, ATR Services SRL, Forest Trans International SRL, EOPS Solutions SRL, Merchant Global Solution SRL, Cargo Delivery SRL, Cargo Service Italia SRL, AMEX Logistic SRL, Elitte Logistic&Forwarding SRL, Logisterra Line SRL, TC Crown Logistics SRL, Eurointertrans Personal Services SRL, Sonico Expert SRL, DCM Spedition SRL, FENI International SRL, Theocrys Trans-Construct SRL, Logikair Cargo SRL, Kiparom Grup SRL, CDC Logistic Transport SRL, Quick Expeditii SRL, Freight Express Intersped SRL, ACN Transport SRL, Exped Cargo Company SRL, Euro Trans Logistics SRL, Top Wash 331 SRL, Georginor Eurotrans SRL	DHL Logistics SRL, Karl Heinz Dietrich International Exped SRL, Dietrich-Honhold Logistics SRL, Rail Cargo Logistics-Romania Solutions SRL, Egetra Romania SA, ATR Services SRL, Forest Trans International SRL, EOPS Solutions SRL, Merchant Global Solution SRL, Cargo Delivery SRL, Cargo Service Italia SRL, AMEX Logistic SRL, Elitte Logistic&Forwarding SRL, Logisterra Line SRL, TC Crown Logistics SRL, Eurointertrans Personal Services SRL, Sonico Expert SRL, DCM Spedition SRL, FENI International SRL, Theocrys Trans-Construct SRL, Logikair Cargo SRL, Kiparom Grup SRL, CDC Logistic Transport SRL, Quick Expeditii SRL, Freight Express Intersped SRL, ACN Transport SRL, Exped Cargo Company SRL, Euro Trans Logistics SRL, Georginor Eurotrans SRL, Air Sea Forwarders SRL, Time Critical Line SRL
Class 3	Unit Cargo Transport Intelligence SRL, RO Freight Forwarders SRL, Shift Spedition SRL, New Tactic ALS SRL, AS World Fastfreight SRL, Professional Border Services SRL, Levon Logistics SRL, Avalon Logistic SRL, Global Star Transport SRL, Selecris Logistic SRL, Alpenlog Solutions SRL, Logistic Option SRL, Ando Trans Divers SRL, Cogen Transport Logistic SRL, Dispo Serv Europe SRL, Util Serv&Logistic SRL, Alean Partners SRL, Euroborder Euroasia Security SRL	Top Wash 331 SRL, Unit Cargo Transport Intelligence SRL, RO Freight Forwarders SRL, Shift Spedition SRL, New Tactic ALS SRL, AS World Fastfreight SRL, Professional Border Services SRL, Levon Logistics SRL, Avalon Logistic SRL, Global Star Transport SRL, Selecris Logistic SRL, Alpenlog Solutions SRL, Logistic Option SRL, Ando Trans Divers SRL, Cogen Transport Logistic SRL, Dispo Serv Europe SRL, Util Serv&Logistic SRL, Alean Partners SRL, Euroborder Euroasia Security SRL

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