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Strategic Application of Cooperative Game Theory in Mitigating Labor Shortages in Post-Pandemic Logistics: A Case Study of Poland

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Abstract: The onset of the global pandemic has underscored the pivotal role of logistics, bolstered by information and communication technologies, in the resilience of supply chain networks. This study investigates the transformative impact of the COVID-19 pandemic on these networks, with a focus on the resultant operational challenges and labor shortages experienced in Poland – a critical hub in European supply chains. The research delves into how cooperative game theory can be strategically applied to address workforce deficits, particularly in sectors vital to Poland's economy, such as food and healthcare. In the context of reduced operations triggered by illness, fatalities, and preventive measures, including travel restrictions, this study elucidates the operational dynamics within supply chain networks through game theory frameworks. It scrutinizes the strategies implemented by major corporations, including Amazon, DHL, Post Office, KFC, and McDonald's, to navigate these challenges. The methodology encompasses an analysis of the network structure of supply chain game theory, tailored to the operational confines of Poland's logistics sector, acknowledging its role as Europe's breadbasket. The findings reveal various approaches to counteract labor shortages exacerbated by the pandemic, drawing parallels with similar challenges in regions like Africa, Asia, Ukraine, Turkey, and India. The study highlights the diverse impacts of workforce disruptions on commodity prices and the revenues of logistics companies within the supply network economy. These insights contribute to a broader understanding of the financial and operational implications of cooperative game theory in the context of global health emergencies. Conclusively, this research augments existing literature by demonstrating the applicability of cooperative game theory in addressing labor shortages under pandemic-induced constraints. It presents a comprehensive analysis of the strategies employed by key players in the logistics sector, offering valuable perspectives on mitigating operational disruptions in times of crisis.

Keywords: Cooperative game theory; Logistic services; Pandemic; COVID-19; Poland

1 Introduction

In the past few decades, the logistics services sector has witnessed escalating costs, primarily attributed to technological advancements. This evolution has intensified competition, particularly disadvantaging smaller firms with limited capacities in competing against larger, globally-operating entities. Consequently, access to efficient logistics services was perceived as a privilege reserved for larger or more affluent entities. However, the period between 2020 and 2021 marked a significant shift in this perception, with the logistics sector becoming increasingly indispensable. The emergence and subsequent global spread of COVID-19 catalyzed profound changes within the logistics industry. During this period, cooperative game theory gained prominence, propelled by factors such as heightened competition, technological innovation, population growth, and evolving human expectations. Previously, logistics services were often seen as a luxury for the affluent or a convenience for the less industrious. Yet, the pandemic highlighted their essential role, as evidenced in several studies [1–3]. Gultekin et al. [1] employed qualitative and fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL) methods to assess the impact of COVID-19 on profit margins and employee welfare in logistic enterprises. Their findings revealed a substantial negative impact on employees, a scenario mirrored in Poland during the pandemic. This situation led to significant labor shortages, with the available workforce demanding higher compensation, thereby driving up prices. Consequently, many larger firms resorted to forming strategic partnerships with other companies, striving to maintain operational viability. This strategic realignment underscored the emergence of a Cooperative Game Theory approach, facilitating a more balanced market share distribution within the Polish logistics sector.

Contemporary advancements in technology, particularly natural language processing (NLP), have assumed a critical role in logistics systems, as outlined in a study [4]. NLP, central to the functioning of the star model, facilitates enhanced communication within logistics services and is integral to the application of game theory. It enables customers to comprehend products and services more effectively while allowing businesses to accurately gauge the needs of their target market. The COVID-19 pandemic underscored the significance of logistic services and the applicability of cooperative game theory, bringing newfound attention to these sectors across various societal domains. Dohn et al. [5] have provided a detailed overview of the business landscape in Poland, noting that approximately 8,000 enterprises span various industries, with over 80% being microenterprises employing up to ten individuals. A substantial proportion comprises small enterprises with 11-49 employees, totaling around 1,015 entities. Less than 5% of enterprises employ up to 250 people, and there are 79 large enterprises with a workforce exceeding 250. This data implies considerable competition within the Polish supply chain market. In recent times, numerous companies have adopted various game theory strategies to secure market share, mitigating the dominance of larger firms and fostering a more balanced competitive environment.

Game theory has introduced innovative ideas and techniques, leading to transformative collaborations among companies. In logistics, cooperative game theory is characterized by the ability of companies to employ quantitative methods to orchestrate process flows systematically, achieving desired outcomes. Supply chain management (SCM), or the logistics network, encompasses diverse facilities and distribution channels that manage material procurement, product transformation, and the final distribution of goods to consumers. According to Rafele [6], logistic performance in many companies is measured through multiple methodologies, underlining that various techniques are applicable in practice, especially in scenarios where events can be quantified in several ways, as is often the case in cooperative game theory.

2 Literature Review

The landscape of global business is continually reshaped by the advent of new technologies, prompting an evolution in operational strategies. In this context, Poland has emerged as a significant example of enhanced efficiency, cost-effectiveness, and the adoption of cooperative strategies. A focused analysis on game theory in relation to logistics costs was conducted [7], revealing that the promotion of logistics services leads to greater financial profitability due to the efficiencies introduced by logistics operations. Furthermore, a systematic review of empirical pricing methods in logistics within the framework of game theory was undertaken [8]. This research centered on the pricing of logistics services, employing content analysis and bibliometric methods to explore the application of game theory in this sector. It has been observed that companies in Poland have increasingly embraced collaboration as a means to augment efficiency, reduce costs, conform to standards, and integrate subsystems with their parent organizations, thereby achieving a broader environmental impact. The influence of cooperative game theory extends into various aspects of daily business operations, encompassing numerical, grammatical, political, and social dimensions. Presently, cooperative game theory represents a streamlined approach to task allocation among employees, playing a crucial role in logistics specialization. The application of cooperative game theory in managing work stoppages illustrates its utility in project management. A study highlighted the role of commercial forwarders as integrators and providers of logistics services. This study delved into game-theoretic methods as they apply to the functionality of logistics service supply chains, through the analysis and comparison of four distinct models across participating units [9]. Furthermore, research into game theory and decision coordination in the agricultural sector was carried out [10]. This study unveiled the presence of uncertainty in agriculture, which, in turn, led to enhancements in logistics services. Another study focused on game theory within the realm of business logistics services [11], examining the comparative competitive structures of two logistics markets.

2.1 Cooperative Game Theory and Logistic Service

Cooperative game theory, as a field of study, primarily focuses on predicting the formation of coalitions, the collective actions of groups, and the consequent mutual benefits. This theoretical framework has significantly influenced the development of symbiotic relationships between manufacturers and retailers within supply chains, indicating a trend towards increased partnerships. The proficiency in managing and directing the operations of one or more firms in a logistics network is crucial. This includes the ability to effectively utilize systems and resources under stable conditions [12], which is fundamental for the long-term success and sustainability of these companies. The application of cooperative game theory in analyzing partnerships is exemplified by the use of the Shapley value as a metric for profit sharing among partners. The structure of the supply chain is pivotal, and the Myerson value is often considered when establishing specific distribution rules within the game's framework. SCM incorporates cooperative game theory as a methodological approach, with the Shapley value providing an equitable solution for distributing benefits and costs among various collaborative groups. Game theory is particularly relevant in scenarios involving multiple actors striving for a common goal, especially when these participants are unequal in status yet collaborate for optimal outcomes. Wang [13] encapsulated cooperative game theory as a mutually beneficial approach, crucial for well-defined supply chain design. The use of logistical game theory extends beyond traditional business applications, finding relevance in the humanitarian sector as well, aiding in the identification of future research opportunities [14]. Furthermore, the widespread adoption of technology has been a significant factor in the advancement of healthcare services [15]. The application of game theory in humanitarian contexts has notably improved healthcare logistics. The efficacy of a logistics system is influenced by various factors, including the location, size, and quality of the service. These attributes play a crucial role in attracting new investors. Additionally, the perception of a company, as shaped by customer feedback and comments, exerts a significant psychological impact on both customers and management.

2.2 Types of Service Provided by Cooperative Game Systems in Logistics

Game theory, in its diverse applications within logistics, employs various game types to address different problematics. The nature of these games is determined by the number of participants (companies, organizations, or institutions), the symmetry of the game, and the level of cooperation among players. Third-party logistics services within a sustainable supply chain were investigated through the lens of game theory [16]. The findings from this research indicated that competition among supply chain members led to enhanced profitability. Moreover, the influence of pricing scheme platforms on logistics services was scrutinized [17]. This study evaluated four distinct pricing models, underscoring the significance of game theory in guiding policymakers during the selection process.

2.3 Cooperative and Non-Cooperative Games

In the realm of game theory, cooperative and non-cooperative games represent two distinct approaches. Cooperative games involve companies engaging in negotiations and agreements to adopt specific strategies. For instance, The Prisoner's Dilemma, a classic example in game theory, illustrates how cooperation can lead to mutually beneficial outcomes. In this scenario, two detainees, Hans and Jobisko, could communicate and agree to stay silent for their collective benefit. Such negotiations exemplify cooperative gameplay, where mutual agreements lead to problem resolution. Nash [18] posited that any desired transferability should be incorporated into the game's structure, rather than relying on external collaboration. An example from the commercial sector can be drawn where a Polish company, Biedronka, faces high advertising costs and seeks to reduce them. The uncertainty about whether competitors like Lidl and Auchan would reciprocate poses a strategic dilemma. However, governmental constraints on Biedronka's television advertising could inadvertently lead to reduced advertising expenses, exemplifying a cooperative game scenario. Conversely, non-cooperative games involve players making independent strategic decisions to maximize their gains. The Prisoner's Dilemma also serves as a prime example of non-cooperative gameplay. Such games are characterized by their precision in outcome determination, owing to the in-depth analysis of the problem at hand.

2.4 Normal Form and Extensive Form Games

In game theory, normal-form and extensive-form games represent two distinct methods of representation and analysis. Normal-form games are characterized by a matrix layout, where strategies and payoffs are tabulated, facilitating the identification of dominated strategies and Nash equilibrium. This matrix form illustrates the strategies employed by players and their potential outcomes. Conversely, extensive-form games are depicted through decision trees, enabling the representation of chance events. They exhibit a tree-like structure, indicating players' options at various nodes and the associated payoffs for each decision. An illustrative example of an extensive-form game might involve two competing companies, such as Biedronka and Lidl, contemplating market entry strategies. The decision-making process and potential outcomes for each company can be effectively visualized using this form.

2.5 Simultaneous Move Games and Sequential

Simultaneous move games and sequential games constitute another classification within game theory. Simultaneous games are scenarios where players make decisions concurrently, without awareness of the other's choices. In contrast, sequential games involve players making decisions after observing the moves of others, though without comprehensive knowledge of the other players' strategies. While simultaneous games are typically represented in normal form, sequential games lend themselves to the extensive form representation. To exemplify simultaneous move games, consider two educational institutions, the Silesian University of Technology and Jagiellonian University Krakow, both aiming to minimize costs in their marketing activities for student recruitment. The strategic dilemma they face is whether to outsource these activities, with concerns about potential enrollment increases at rival institutions. This situation illustrates the simultaneous decision-making process where each institution must decide independently whether to outsource or not.

2.6 Constant Sum, Zero Sum, and Non-Zero-Sum Games

In the domain of game theory, constant sum, zero-sum, and non-zero-sum games represent distinct categories based on the aggregate outcomes for all players. A constant sum game maintains a fixed total outcome irrespective of individual player results. A subset of this, the zero-sum game, is characterized by an aggregate outcome of zero, where one player's gain equals the loss of another, rendering the overall resource pool unaffected by individual strategies. Contrastingly, non-zero-sum games do not adhere to a zero aggregate outcome. Interestingly, such games can be transformed into zero-sum games through the introduction of a dummy player, whose losses counterbalance the net gains of the actual participants. Chess and gambling are classic examples of zero-sum games, epitomizing the principle where one participant's gain directly equates to another's loss. However, cooperative games are typically non-zero-sum, as they involve scenarios where players either win or lose collectively.

2.7 Symmetric and Asymmetric Games

Furthermore, game theory distinguishes between symmetric and asymmetric games. Symmetric games entail all players adopting identical strategies. These games are more prevalent in short-term engagements due to the limited strategic choices. In these scenarios, decision-making is influenced by the strategies rather than the identities of the players. The prisoner's dilemma serves as an example of a symmetric game. On the other hand, asymmetric games involve varied tactics among players, where a strategy beneficial for one player may not be equally advantageous for another. Decision-making in asymmetric games is dictated by the diverse strategies and choices of the players. A real-world example of an asymmetric game is observed when new companies enter different market segments, such as Bolt Taxi entering the taxi industry while Uber collaborates with McDonald's in food delivery. Monostori et al. [19] highlight that cooperative theories are instrumental in addressing organizational conflicts arising from rigid systems. These theories elucidate that centralized systems, when subjected to internal and external factors, often encounter production-related issues. Cooperative theories are posited as effective mediators in resolving such intra-organizational conflicts.

2.8 Steps Towards Cooperative Theory in Logistics During COVID-19

In addressing the challenges posed to supply chains during the COVID-19 pandemic, cooperative game theory has emerged as a pivotal tool. Figure 1 delineates the various stages essential for fostering effective cooperation within logistics frameworks, as corroborated by technical communities in game theory [20, 21]. The utilization of wireless sensor networks, which monitor and record environmental conditions and transmit this data, has become increasingly significant [22]. These sensors' capabilities in tracking shipments and relaying critical data to management systems are integral to the efficacy of logistics operations. Moreover, the enhancement of logistical service security, a key aspect of game theory, plays a crucial role in elevating customer satisfaction. Advancements in sensor technology have facilitated remote monitoring over expansive geographic areas [23], proving indispensable for logistics systems, particularly in the distribution of consumer goods. This paper undertakes an analysis of SCM through the lens of Game Theory. The objective is to demonstrate the applicability of Cooperative Game Theory as a methodological approach for the analysis of supply chains. A defining characteristic of a supply chain is the cooperation it necessitates, achieved through well-defined process flows.

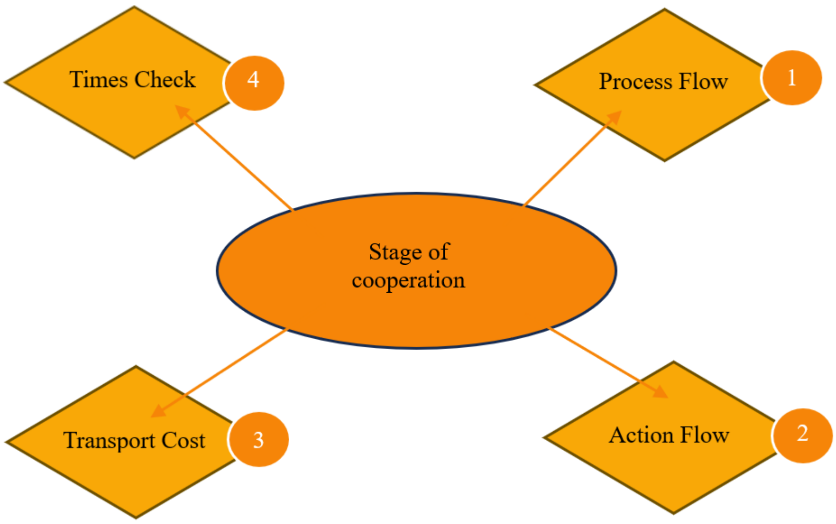

Figure 1. Stages in cooperative game theory in logistics

Process flow: Game Theory plays a pivotal role in analyzing discrepancies in process flow, particularly when integrating scenarios involving two or more dynamic or rational circumstances, including intelligent players. This analysis is integral to human decision-making and management within an organization's operations. Cooperative gaming, in this context, provides a method for distributing resources or items within a system.

Action flow: As a decision-making tool, cooperative game theory aids in strategic choices across various scenarios. Its versatility renders it applicable in diverse fields such as biology, technology, philosophy, and science. The onset of the COVID-19 pandemic catalyzed a shift in competitive dynamics, leading companies to collaborate in areas like recruitment, employment policies, and joint deliveries. This collaboration has fostered greater unity in the industrial marketplace and society in Poland, enabling both small and large firms to partner on divisible shipments.

Transport cost: Gharehbolagh et al. [24] have demonstrated that combining transportation costs of multiple companies through shared logistics can lead to significant expense reductions. This strategy, a hallmark of cooperative game theory, was particularly evident during the COVID-19 pandemic, as companies divided their logistics operations. Notably, larger corporations formed alliances with smaller, locally established firms, optimizing deliveries in specific regions. An example of this is seen in how companies like McDonald's, KFC, and Kabab utilized a singular delivery service such as Uber to minimize costs.

Time checks: This process involves merging non-profit logistics companies with profit-oriented logistics firms. Balza et al. [25] discuss how non-profit organizations assess procedures, costs, and order placements to analyze the distribution of resources used by key stakeholders. This evaluation is essential for determining the feasibility of the proposed collaborative framework. The objective is to identify the most cost-effective method of product delivery within the network and to enable various suppliers to assess the effectiveness of their cooperation.

2.9 Types and Characteristics of Logistic Service Industry

In the logistics service industry, the efficacy of various logistical methods is paramount for companies offering products. This aspect is crucial in surmounting challenges, maintaining precise inventory records, and ensuring successful delivery of products. Three primary types of logistics services are typically employed, each serving distinct objectives. The involvement of a company like Bonded Service, which provides support in all these logistics types, can significantly enhance operational efficiency.

Freight services: The transportation of large items or substantial quantities necessitates the use of freight shipping services. In the United States, this often involves long-distance trucking or rail transport, while sea transportation predominantly utilizes cargo ships. Freight services facilitate the delivery of sizeable shipments to customers or the transfer of goods from ports to warehouses. For larger loads, Full Truckload (FTL) freight services are required, whereas Less-Than Truckload (LTL) services are suitable for smaller quantities, offering cost-sharing benefits with other parties. Based on specific needs, a company like Bonded Service can manage its fleet for freight delivery or collaborate with other LTL carriers.

Courier services: For smaller orders, time-sensitive deliveries, or items needing extra care, courier services are the preferred choice. Esteemed courier companies, including Fedex and UPS, alongside local couriers, provide secure and rapid delivery directly to recipients, minimizing product damage risks.

Bonded warehouse services: Managing inventory effectively is a critical component of logistics. Warehousing plays an indispensable role in this context. Secure storage facilities for products prior to shipment are necessary, along with efficient and accurate systems for cataloging and tracking inventory until it reaches customers. These warehousing responsibilities are integral to the logistics process.

2.10 Reasons Leading to Cooperation in Logistics

This section explores the advantages and challenges inherent in horizontal cooperation among Logistics Service Providers (LSPs). Research findings suggest a consensus among LSPs on the potential benefits of horizontal collaboration to enhance profitability and service quality. It has been observed that the challenges faced by LSPs opting not to cooperate are similar to those encountered by their collaborating counterparts. A significant hurdle identified is the establishment of a trustworthy entity to manage the collaboration and ensure an equitable distribution of benefits.

Strategic alliance: This term refers to a collaborative arrangement between two or more organizations, also known as a strategic partnership. Such non-equity cooperation agreements represent an initial step towards a cooperative strategy, enabling firms to collectively pursue mutual benefits. Distinct from a joint venture, these alliances do not entail the creation of a new entity or formal ownership ties. Instead, the collaborating entities operate under mutual agreements to support each other in organizational or business functions. The primary objective of these alliances is to create a mutually beneficial scenario, ensuring gains for all parties involved. These partnerships lay the groundwork for joint research, product enhancement, and technology sharing. Through sharing research and development (R&D) information, partners can collaborate on technological advancements, develop new market products, and establish networks for distribution. Examples of such strategic alliances include collaborations between

HP and Intel, Microsoft and AT&T, and UPS. These alliances negate the need for individual companies to invest heavily in processes to access new opportunities.

Benefits of strategic alliances include:

- Collaboration on technology development or novel product creation.
- Significant enhancement of competitiveness.
- Improved efficiency within the supply chain.
- Acquisition of new competencies.
- Expansion of industry opportunities through collaborative efforts.
- Enhanced market access via joint marketing agreements.

2.11 Logistic Service and Cooperative Theory

In the business context, Game Theory is primarily utilized by managers to anticipate the strategies and plans of collaborators and competitors, focusing on task completion and enhancing customer satisfaction. This approach diverges from the azimuth concept in business as presented [26], which forms the basis for considering the establishment of advanced international communication routes across the European continent. This concept is a subset of the cooperative game system. Game theory for resolving transshipment challenges was explored [27, 28], employing the logistics network application known as the Shapley Value within cooperative game theory. This framework is an effective tool for predicting outcomes or results of interactions among various players or competitors, where the actions of one have a direct impact on others, prompting reactive strategies. The application of the Critical Path Method (CPM) work breakdown structure will be used to elucidate how the cooperative system functions within a company's game theory framework. Game theory is instrumental in analyzing discrepancies in process flow and integrating scenarios involving two or more dynamic situations with intelligent agents. Thus, it plays a crucial role in the decision-making and management processes within a company's activities. Companies can leverage this model to coordinate work and promote efficiency among employees, thereby achieving desired outcomes and enhancing customer satisfaction.

3 Evaluation of Supply Chain Network and Game Theory Modelling Under Labor Constraints

In the examined market, two companies, denoted as A1 and B2, operate within the supply chain network economy. Firm A1 specializes exclusively in retailing products, while Firm B2 engages in production, retail, and distribution. Both firms face competition in key areas such as transportation, storage, and distribution of products to demand markets. It is observed that A1, with its longer market presence, has acquired a larger customer base and more extensive market knowledge compared to B2.

3.1 Pre-Pandemic Era and Logistics Services

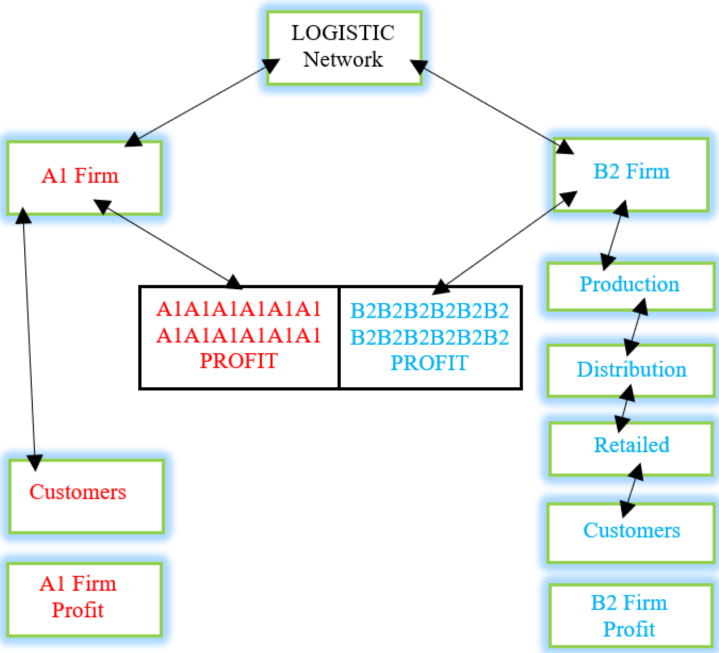

Figure 2. Situation of logistic services before COVID-19

As indicated in Figure 2, larger companies were experiencing suboptimal profits. Factors contributing to this included:

- Unnecessary competition leading to market saturation.
- An increase in supply costs impacting overall profitability.
- Market share monopolization hindering the entry of smaller firms.
- Compromises in product quality.
- Strategies aimed at preventing or eliminating market entry by smaller firms.

This scenario underscores the challenges faced by many companies, particularly smaller entities struggling to compete with larger firms. With the onset of the COVID-19 pandemic, a shift towards partnerships between large and small firms became evident. Such collaborations led to a more balanced profit distribution within the industry. Figure 2 demonstrates the disparity in profit margins within logistic services prior to the pandemic, highlighting the significance of cooperative strategies in business.

In subsequent chapters, the necessity for cooperation in logistic services will be further explored, elucidating the benefits arising from such alliances.

Post-COVID-19 cooperative game theory

Figure 3 presents a visualization of how companies have adapted their operations in the market post-COVID-19. A notable reduction in competition is observed, alongside the emergence of opportunities for new companies to enter the market and coexist with established, larger firms.

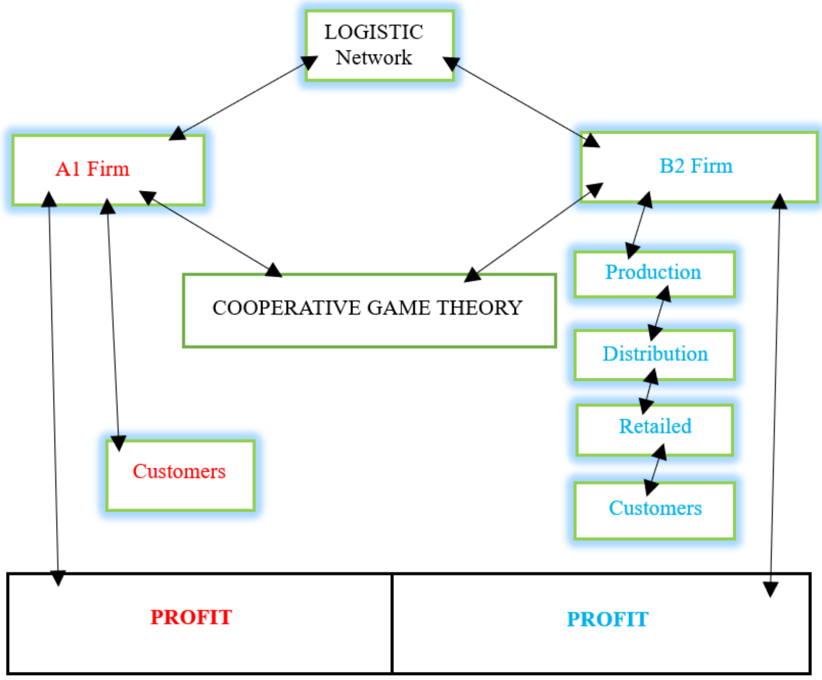

Figure 3. Situation of logistic services after COVID-19

The post-pandemic landscape of logistics services has yielded several benefits:

- The establishment of uniform and necessary competition, leading to a healthier market environment.
- A decrease in supply costs, enhancing overall efficiency.
- The attainment of a balanced market share, mitigating monopolistic practices.
- Improvement in the quality of products offered.
- The inception of new firms and re-entry of small firms into the market, revitalizing industry dynamics.

As depicted in Figure 3, the importance of cooperation among firms is underscored, given the numerous advantages it entails. Subsequent chapters will delve deeper into the necessity of fostering cooperation in logistic services, elaborating on the positive impacts of such collaborative approaches.

3.2 Factors Necessitating Cooperative Game Theory

In the post-COVID-19 era, several factors have underscored the need for the application of cooperative game theory. An integration of logistics game theory with financial services has been the subject of investigation [29].

In contexts such as disaster relief, the construction of a cooperative framework encompassing both financial and logistical services is imperative. Furthermore, advancements in medical sensors, wireless sensor networks, and cloud computing have revolutionized monitoring and computation processes [30]. A study focusing on cyber-physical systems in the context of logistics game theory examined these developments. The reliance of contemporary logistics systems on digital services, particularly wireless sensor networks, is a significant factor in this regard.

Another compelling factor is the negative impact of competition on the economy. It has been observed that competition can diminish efficiency [31], escalating operational costs, distribution expenses, and the cost of goods and services. To sustain and thrive, companies are increasingly adopting various cooperative game theory strategies to minimize costs and maximize profits. Expenditures in stock management, such as inventory costs, are also influenced by competitive dynamics. Branding strategies, in response to competition, not only affect company profits but also consumer behavior in waste disposal. For instance, the use of plastic containers designed to resemble glass containers not only impacts profitability but also alters disposal patterns, thereby significantly affecting the waste management system and, consequently, the environment in which customers reside.

In recent years, the issue of business continuity has become increasingly prominent. Numerous firms have ceased operations due to a lack of capital and survival means, impacting both customers and governments. Customer trust, once established with a company, especially in supply sectors, becomes vulnerable when such companies exit the market. This loss of trust not only affects the immediate customer base but also hinders the entry of new firms into similar market segments. Maintaining customer loyalty is a critical challenge in business; once achieved, it necessitates careful management for the sustained benefit of the economy and future firms. Cooperative theories play a vital role in enabling companies to maintain longevity and operational stability.

The prevalence of high oligopoly in the market poses significant challenges to global, local, and urban economies. Dominance by large firms creates barriers for smaller entities to sustain or initiate operations. The application of cooperative game theories can mitigate these barriers, fostering more equitable and optimal market conditions.

Another critical gap exists between e-commerce platforms and LSPs. In the traditional economic era, many operations were manual. However, the digital economy's advancement has shifted most activities to virtual and online platforms. The COVID-19 pandemic further accelerated this transition, with new regulations promoting limited physical contact. This shift has seen educational institutions, companies, and healthcare sectors increasingly adopting information and communications technology (ICT) tools for daily operations. The collaboration between companies and tech firms has become more prevalent, yet a substantial gap remains in integrating these systems. To provide efficient services, companies require robust negotiations and effective cooperative theories. Poudevigne et al. [32] underscore the importance of developing solutions for organizations to support a globally digital world, as activities increasingly move online. To address this need, logistics services must adopt a high-level cooperative theory approach, enabling both tech and logistics companies to maximize shared profits and adapt to evolving digital landscapes.

4 Discussion

The implementation of a cooperative game system is recognized as crucial by astute business executives, understanding its role in orchestrating well-coordinated logistics. It has been identified that seamless logistics, facilitated by the effective application of a cooperative game system, are fundamental in meeting customer demands, maintaining pace with internal management systems, and enhancing profit levels, thereby outperforming competitors.

- Resource allocation: According to Sahaym et al. [33], cooperative theories propose equitable resource allocation methods, rendering problem-solving in business processes more cost-effective. These theories encompass optimistic, pessimistic, and most likely estimates regarding time, cost, and capacity for each action in a firm's lifecycle and operations.
- Promotion of advanced joint delivery services and customer satisfaction: The cooperative game system facilitates the joint delivery of services, significantly enhancing customer satisfaction.
- Reduction of company costs: A substantial part of operational expenses in many businesses is attributed to logistics, including transportation costs. Collaborative efforts among shippers to consolidate transportation needs can lead to a collective fulfillment of these requirements at a reduced cost.
- Prevention of shortages: The maintenance of a constant supply is crucial to avoid market shortages, which are often accompanied by price increases. Ensuring a steady supply aligns with market prices, benefiting the customer.
- Effective management: Collaboration between two or more firms allows for the exchange of diverse ideas and strategies, leading to more effective management systems.

Advantages of logistic service in the cooperative sector

The implementation of cooperative game theory in logistics offers several advantages, detailed as follows:

- Resource limitations: Financial stability in cooperative environments hinges on member contributions and

borrowing capabilities from state cooperative banks. The typically modest membership fees, affordable for lower and middle-class individuals, limit the accumulation of substantial resources. Thus, cooperative strategies may not be viable for wholesalers or large-scale enterprises requiring significant capital.
- Management efficiency: In a cooperative setting, members are provided with superior goods and services at cost-effective prices. The environment extends financial assistance to its members at concessional rates, supporting the establishment of production units and facilitating the marketing of products for small business owners and agricultural producers.
- Democratic management: Management of the cooperative society is undertaken by elected members from among themselves. Each member possesses equal rights and contributes actively to the development of society's policies, ensuring democratic operation and equal significance of all members.
- Stability and continuity: Cooperative societies exhibit enduring stability and existence, unaffected by the death, insolvency, or incapacity of individual members. The distinct legal identity of these societies contributes to their prolonged operation. The society's continuity is maintained regardless of membership changes unless unanimously agreed upon termination by all members.
- Economic operations: Cooperatives operate economically by eliminating middlemen, with society members providing intermediary services at minimal costs. This leads to reduced operational expenses, both recurring and non-recurring. Economies of scale in production or procurement automatically lower the purchase price of goods, subsequently reducing the selling price.

5 Conclusions

The findings of this research study underscore the significant disruptions in labor and production flows globally, which have been a direct consequence of the prevailing health crisis. On a positive note, this period has led to the elimination of certain practices prevalent among large companies. Prior to the COVID-19 pandemic, a notable imbalance in profitability among organizations within the supply chain network was observed, along with variances in operational methodologies. The pandemic has emphatically highlighted the necessity of adopting gaming concepts to effectively address the global shortage of employees. For instance, during the COVID-19 outbreak, extensive cooperation among companies in Poland became crucial to adequately meet customer needs. Larger corporations reached agreements and signed memorandums of understanding with industry retailers to enhance the distribution of products and services. This period witnessed unprecedented cooperation among institutions with diverse affiliations, united for a common purpose.

The importance of cooperation, brought to the fore during the COVID-19 pandemic, continues to influence the operational strategies of many establishments in Poland. This shift in approach demonstrates a significant adaptation in business practices, underscoring the potential of cooperative strategies in navigating unprecedented challenges.

Author Contributions

Conceptualization, Eric M. and Lilian K. S.; methodology, Eric M and Lilian K S.; formal analysis, Eric M: Lilian K S and Killian F Y.; investigation, Lilian K S; and Eric M.; resources, Killian F Y, Eric M.; data curation, Lilian K S.; writing—original draft preparation, Lilian K S, Eric M. John A. A, and Janet A O.; writing—review and editing, Eric M, Lilian, John A. A, and Janet A O..; visualization, Lilian K S, Killian F Y and Eric M.; supervision, Eric M.; project administration, Lilian K.; funding acquisition, Eric M and Killian, Editing and writing—final.: John A. A, and Janet A O.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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