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Developing sustainable logistic strategies in the context of cognitive biases

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Abstract—**Cognitive biases often occur even in the decision-making process of highly qualified company managers due to the drive for efficiency and time pressure in operations. At the same time, there are also long-term strategic decisions where time pressure is no longer a factor, and yet cognitive bias appears, which has to be considered properly. In strategic issues, decision- makers tend to see their wishes and desires rather than the objective reality. The proposed system of fuzzy indicators based on technical and objective data supports decision-making between logistics strategies by mitigating cognitive biases, which is extremely important in the logistics field, where the decisions have to be made partly based on subjective, vague, or uncertain parameters.**

Index Terms—**logistics systems, cognitive bias, Push and Pull strategy, fuzzy description**

I. Introduction and Background

Cognitive infocommunication aims to create complex perceptual computing systems that effectively support human-machine communication [38]. The development of new methods, mathematical modeling, learning techniques, and related behavioral research will also help to better understand perceptual and cognitive brain processes [39]. For human-machine communication to be effective in the course of logistical strategies, it is necessary to identify and avoid cognitive biases in decision-making, so that its evaluation is not only based on intuition and subjective judgment alone. Data and pre-processing, standardization, and quantification are necessary to avoid associated biases.

A cognitive bias is a systematic deviation from rationality and logical, reasonable thinking and behavior. Cognitive biases are phenomena that influence thinking on experiences, intuition, and perceived things [1], thereby turning an objective decision into a subjective interest system [2].

Logistics, as a specialized field, typically requires decision-making at a daily level for the staff implementing logistics processes. On the other hand, logistics is often not seen as an independent field of expertise. As a consequence, the importance and necessity of the processes concerned are not assessed in sufficient depth, and decisions are based on intuition rather than rational decision-making. The time pressure characteristic of the logistics field [3] also significantly affects cognitive biases. Due to the particularities of logistics, there are departments where self-interest distortion [4,5] appears among cognitive biases.

People's thinking works together with simplifications, and cognitive biases [6]. For this reason, cognitive bias often occurs at the decision-making level in objective interest systems, which can be interpreted in several ways [7]. A systematic deviation from economic rationality in a company's decision-making model is called bias [8]. Psychologist Gary Klein [9], - who studied intuition in a scientific context at length and analyzed its effects in decision-making situations - named it a recognition-based decision model [9]. He concluded that intuition-based decisions only help managerial decisions in a predictable environment, similar to what has already been experienced countless times. So, decisions based on intuition are only acceptable if they are based on real experience [10].

The starting point for the appearance of cognitive bias is always a situation where a person responsible for decision-making receives information that they must incorporate into their decision-making mechanism [11]. They try to support the decision-making processes objectively, by examining facts and data [12]. As a result of unconscious prejudices, "beliefs", and expected results, the examination of facts and data becomes subjective, and decision-making takes place without self-checking [13].

Logistics decision-making takes place at different levels: it can distinguish between tactical, operational, and strategic decisions, which can be grouped according to a time horizon into short-, medium- and long-term decisions. In this paper, the 5 categories of cognitive biases will be described [14] and identified in the course of corporate decision-making and how and at what level these biases appear in the course of logistics decision-making will be shown.

The choice between Push and Pull systems are examined [15] as well as providing insight into the cognitive biases that appear during decision-making related to these systems. As it is not only determined by whether the production takes place to customer demand or stock, decision-making is often influenced by the cognitive biases that arise from fears about stock issues. First, where the names of the Push and Pull systems come from is mapped [16], and then the history of their development is presented [17]. After clarifying the concepts, it is explained which cognitive biases can appear during the logistics-related decision-making mechanism. Further, the limit will be examined at which a product can be reasonably defined to have

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a Push or Pull logistics strategy associated with it. For this purpose, a fuzzy measure is proposed that can be used to clearly identify the logistics strategy for the given product and the company's production.

The choice between Push and Pull logistics strategy for sustainability

One of the big trade-offs in Push-Pull is inventory versus delivery cost. This gives rise to logistical strategy decisions, during which cognitive biases may emerge as a significant deciding factor. The cognitive biases that emerge during the logistics decision-making process are introduced in Chapter 3, and the Push and Pull logistics strategies are discussed in detail in Chapter 4.

In this article, an analysis was carried out on the ScienceDirect and Scopus site on whether sustainability as a goal is reflected in the choice between Push and Pull logistics strategies. The aim of this publication is to present a methodology; therefore, the literature analysis is limited to these two databases.

An analysis was conducted on ScienceDirect and Scopus, first examining all publications, then narrowing it down to the last 5 years (2019-2024) and the 15 years before that (2004-2018), where the keywords in Table 1 and their contexts were included in the filtering: "push pull" AND (logistics OR "supply chain management") AND sustainability on ScienceDirect on the 10th of April 2024.

TABLE I.
NUMBER OF RELEVANT PAPERS. KEYWORDS: "PUSH PULL" AND (LOGISTICS OR "SUPPLY CHAIN MANAGEMENT") AND SUSTAINABILITY

PERIOD	KEYWORDS / RESULT SCIENCEDIRECT	NUMBER OF PUBLICATIONS	
		Science Direct	Scopus
2000-2024	Summary	326	1065
2019-2024	Last 5 years	159	834
2004-2018	15 years before the last 5 years	141	231

Table 1 shows that the search did not yield a large number of results, suggesting that there is currently little research on the relationship between logistics strategies and sustainability.

To examine the keywords of the publications, using the VosViewer software, which helps us analyze the relationships between keywords in the publications, showing the direction of the articles written in recent years in the context of Push and Pull logistics strategies and sustainability

Visualizing all the results of ScienceDirect (Appendix 1), it can be seen that the supply chain appears directly next to sustainability from 2018, and Industry 4.0 appears in 2021-2022, in addition to the circular economy, strategy, blockchain, technology adoption, and flexibility keywords. This led to the conclusion that professionals have recognized the need to develop long-term logistics strategies to achieve sustainability, yet the publications that have appeared have not focused on this aspect.

Based on the keywords, a visualization was made from the Scopus database, where the minimum number of occurrences was set to 20 due to the large number of keywords. In Appendix 2 it is already clear that from 2019-2020, terms related to environmental will also appear: environmental management, environmental technology, environmental regulations. Hence, environmental measures related to sustainability have become more prominent in the last 5 years. Appendix 2 also illustrates that in 2022, the keywords consumption behaviour and human will already appear, highlighting that more publications have already examined the human perspective in terms of logistics strategies and sustainability.

This paper aims to highlight the need to examine the Push and Pull systems and the cognitive biases in the choice of strategies in terms of sustainability, as the logistics strategy is fundamental to this.

II. LOGISTICAL ASPECTS OF COGNITIVE BIASES APPEARING IN CORPORATE DECISION-MAKING

In logistics, sustainability is primarily a strategic decision [18, 19]. Inappropriate logistics sub-processes damage the environment by purchasing unnecessary equipment, parts or packaging [20]. If logistics strategies are not internally coherent, this has an impact on sustainability. The presence of cognitive biases can be recognized in almost all areas of logistics. For their appearance to become clearly identifiable, cognitive biases are first described in the following.

Cognitive psychology basically defines two thinking systems. One system is characterized by conscious and processed thoughts [7], this is what is called "rational thinking" [21], which is not dealt with in this publication. The other thinking system is characterized by automatic and intuitive thoughts. The presence of experiences, prejudices, and assumptions causes cognitive biases in the system of thinking processes, thereby simplifying decision-making situations [22].

From the point of view of corporate decision-making, Olivier Sibony [14] classified cognitive biases into five main categories, within which 23 different types (see Appendix 3) were distinguished. Logistical aspects of cognitive biases appearing during corporate decision-making are as follows:

Pattern-recognition biases: Arise when a company tries to follow the example of a successful person by incorporating the same decisions into corporate strategies, but these decisions are not always appropriate for the company, which has a completely different corporate culture and product range [14].

Action-oriented biases: Refers to the cognitive biases that appear in the actions, which usually result from overly optimistic planning [23].

Cognitive inertia: When a process does not start due to certain facts and data. Loss aversion is one of the most powerful cognitive biases, which hinders change and the development opportunity that comes with it [24]. Loss aversion is of great importance in the subfields of logistics [25].

Self-interest biases: In some cases, for managers, the most important thing is not the company's lost money, but the loss of prestige resulting from their failure. Self-interest bias, also known as limited ethics, refers to cognitive biases that cause decent people to unknowingly show unethical behavior [4, 26].

Group biases: The cognitive biases created in the group mean that one individual's opinion has a significant influence on the decision-making structure of other people [27]. The effect of group bias is significant for the preparation of logistics strategies since logistics is often still negatively evaluated.

Based on the five categories, it can be clarified that the presence of cognitive biases in the decision-making mechanism related to logistics strategies can be definitely identified.

During the work of the persons responsible for the implementation of logistics processes in corporate decision-making, the logistics mindset often appears, casting logistics in a bad light, and causing in turn extra work and costs for the company. In practice, this means that the work of the people responsible for the implementation of logistics processes is treated as unwelcome and an unnecessary cost, so the managers of smaller companies tend to follow this way of thinking, both in terms of their work and their financial appreciation.

III. Concepts of Push and Pull strategies

The terms Push and Pull first appeared in Richard J. Schonberger's book in 1982 [16], comparing the Western-oriented "Push production system", which is based on the design philosophy of production resources and material resource planning; and the Japanese "Pull production system", which included the control technique based on Kanban logic together with the expectations of the Just In Time concept [36].

Nowadays, the definition of Push and Pull is already defined [15, 17], but professionals in the industry still often use the concepts of Push and Pull incorrectly, and consequently make bad strategic decisions. One of the big trade-offs in Push-Pull is inventory versus delivery cost. This gives rise to logistical strategy decisions, during which cognitive biases may emerge as a significant deciding factor.

In the case of a Push system, preliminary demand surveys are carried out, based on which the production program is prepared, the raw material is procured in the appropriate schedule, and then the production program is executed (Material Requirements Planning and Manufacturing Resource Planning MRP II).

In the case of Pull systems, production is always initiated by customer demand. In this way, the minimum stock level of the finished product can be ensured, but on the other hand, it means a longer lead time for the customer. The Just In Time (JIT) system enjoys great popularity among companies. However, its name causes a misunderstanding in the common language. From whose point of view is the product just in time? Undoubtedly from the point of view of the inventory as, due to the lead time, the customer always ends up waiting.

There is a trade-off in logistics between inventory or delivery (mobility). It connects to logistics strategies if the product is Push, more stock is needed and less transport, so you have less mobility, which means you have lower CO_2 emissions and less noise pollution. Conversely, if the Pull start strategy is investigated, there will be a higher number of deliveries associated with the freight transport, as the delivery of inventory is determined by customer demand. However, cognitive mobility [40] can lead to a deviation from what seems to be a good solution based on objective calculation.

The history of the development of Push and Pull systems dates back to the appearance of Material Requirements Planning [28], which enables the planning of material requirements for production and procurement [30]. The starting point was the number of final products defined in the production program, next the bill of materials was determined based on the material requirement, and then the gross component and raw material requirement [31].

The Material Requirements Planning (MRP) system was developed by Joseph Orlicky for the Toyota Manufacturing Program in 1964 [32]. Simultaneously, Black & Decker was the first company to use MRP. By 1975, MRP was implemented in 700 companies, and Joseph Orlicky's book Material Requirements Planning [32] was published in the same year. In 1983, Oliver Wight put the master schedule, rough capacity planning, capacity requirement planning, and other concepts into the classic MRP, thereby creating the basic idea of Manufacturing Resource Planning (that is MRP II) [33].

The Pull logistics strategy started with the Kanban system, which was introduced in the 1940s in supermarkets [32]. The order was determined based on the seller's inventory [15]. They only ordered more when the stock of the item was significantly reduced, thus optimizing the flow between the supermarket and the consumer. Toyota engineers noticed this method and, led by Taichi Ohno, investigated how it could be applied to work processes in the industry [33]. The Kanban initiates an action to replace the quantity consumed, so it is assigned to each production lot within the Just In Time (JIT) system [34,35]. To make Kanban effective, cycle time must be assigned [36].

Cognitive biases appear during decision-making between Push and Pull systems – case study

When a new product is introduced, the decision regarding the logistics strategy associated with it is generally made rationally and based on sound arguments. However, some concerns often lead to cognitive biases during the decision-making process related to Push and Pull strategies [17, 28], such as fear of the Bullwhip effect [29], lack of supplies, etc. An improperly chosen logistics strategy can cause supply disruptions and is also reflected in the company's processes. For example, the size of the warehouse is not only determined by how many products the company sells per month, but it is also significantly influenced by whether the manufactured products are made in a Push or Pull system. A product made entirely in the Pull system is not stocked, or only for a very short time. Products manufactured in the Push system are produced in large quantities [15], so they require a larger storage capacity.

Furthermore, it is a common problem for companies to use a Pull strategy until the managers are faced with the fact that the logistics processes are not working well. When investigating the reasons, it turns out that the Pull strategy was chosen because the manager who made the decision had previously worked for a company where the products were associated with the Pull logistics strategy. The decision is therefore accepted without any examination of the external circumstances. Considering Sibony's classification [14] (see Appendix 3) the presence of Overconfidence bias can already be clearly identified during decision-making (see Table.2).

TABLE II.
CROSS-CORRELATION OF BIASES (OWN COMPILATION BASED ON [14])

		Own knowledge	
		Underestimates	Overestimates
Position (power)	Underestimates	1 - Loss Aversion	2 - Experience bias
	Overestimates	3 - Halo effect	4 - Overconfidence

A cognitive bias appeared in the manager's decision-making mechanism [10], which, based on experience so far [11], led to the conclusion that the logistics strategy being implemented made the previous company successful, even though the product requires a completely different logistics environment. As a result of the appearance of the Halo effect [24], the appropriate logistics strategy was not implemented. The decision is partly based on existing work experience, so the presence of Experience bias [1] can be identified. After that, Status Quo [4] is a common phenomenon, when the management sticks to the originally formed decision. When it turns out that the right strategy has not been chosen for the given product, Loss aversion, Uncertainty aversion, and Hindsight bias [4; 14], which often arise during further decisions, appear as well.

IV. DEMARCATION OF PUSH AND PULL LOGISTICS STRATEGY

Push and Pull systems are determined based on the needs related to the product [15], but in many cases during production, it cannot be clarified whether a specific product is manufactured in a Push or Pull system. Fig. 1/a shows that the Completely Push System is when first the forecast (F) is made, the raw material is purchased, and only then does production begin, with the finished product then being sold by the vendors. In contrast, Fig. 1/b shows that only after the customer's order do the raw material procurement and production start. Then, when the order is fulfilled, the customer receives the product. In the Hybrid Push/Pull system shown in Fig. 1/c, the first half of the system behaves as a Push. The Material Decoupling point appears at the same time as the semi-finished stock, after which the product starts to behave as a Pull.

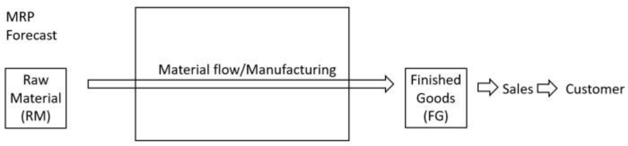

Fig.1/a. Completely Push System (MTS – Make-to-stock)

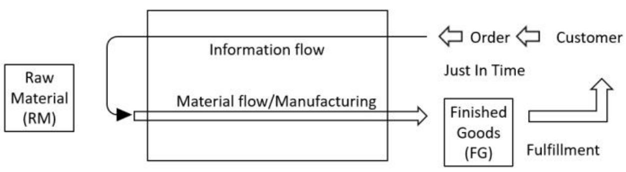

Fig.1/b. Completely Pull System (MTO – Make-to-order)

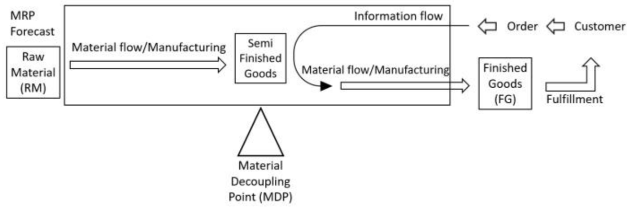

Fig.1/c. Hybrid Push/Pull System with Material Decoupling Point

V. FUZZY ASSESSMENT FOR THE DEMARCATION

An additional question is what characteristics can be used to determine whether it is Push or Pull. The first approach can be based on how many phases, for how long, and at what cost the material flow will proceed. For example, Fig. 2. shows a sequential production line

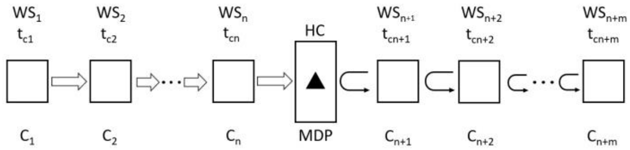

Fig.2. A sequential production line

Legend for sequential production line

Symbol	Meaning
WS_i =	The i^{th} Work Station (i= 1…n+m)
t_{ci} =	Cycle Time at WS_i (i= 1…n+m)
C_i =	Production Cost at WS_i (i= 1…n+m)
HC =	Holding Cost ($_{RM}$- raw material, $_{FG}$- finished goods)

The raw material arrives by WS_n, in the Push system. After that, it goes to the warehouse, and when an order comes, it will be pulled in small Kanban circles until WS_{n+m} (Fig.2). The MDP coincides with the entry into storage. There are $n+m$ workstations in total. Of these, n units are Push-based and m are Pull-based, the proportions of which are determined:

$$\text{Push: } \frac{n}{n+m} \tag{1}$$

$$\text{Pull: } \frac{m}{n+m} \tag{2}$$

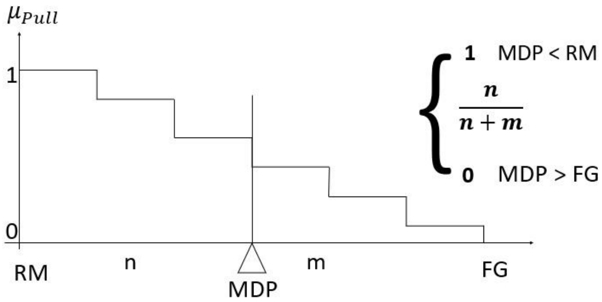

Fig.3. Fuzzy membership function of being pull calculated by (2)

This relationship considers only the used capacity in discrete numbers and can be used if the cycle times are nearly constant as shown in Fig. 3. For the representation of the actual status of the production concerning pull and/or push strategies fuzzy sets are introduced in which the membership values of being "Pull" are calculated at different accuracy, depending on what features of the production are taken into account (see Eq. (4), Eq. (6) and Eq. (8))

If the workload is not evenly distributed, it is necessary to consider the actual time spent in production (see Eq. (4)):

$$\text{Push: } \frac{\sum_{i=1}^{n} t_{ci}}{\sum_{i=1}^{n} t_{ci}+\sum_{j=n+1}^{n+m} t_{cj}} \qquad (3)$$

$$\text{Pull: } \frac{\sum_{j=n+1}^{n+m} t_{cj}}{\sum_{i=1}^{n} t_{ci}+\sum_{j=n+1}^{n+m} t_{cj}} \qquad (4)$$

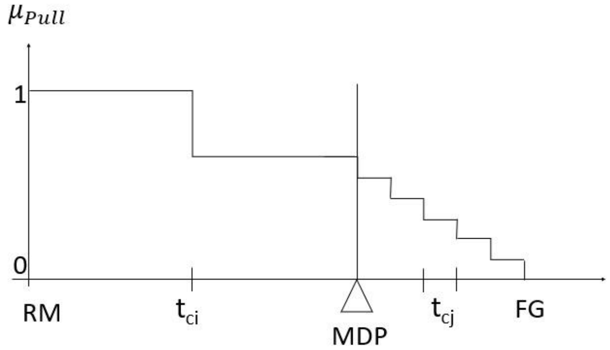

Fig.4. Fuzzy membership function of being pull calculated by (4)

By comparing Fig.3. and Fig.4. it is clear that the position of MDP alone is not enough to assess the "pullness" of the system. Without considering the cycle times judgement will be biased.

However, it does not yet include the complexity of the work process, for example, the processing may be different, such as rust protection, roughing, or fine machining. Hence a cost factor also must be included to determine the hourly price of the machine. In this case, C_i and C_j are introduced to represent the costs at each workstation (see Eq. (5) and Eq. (6)):

$$\text{Push: } \frac{\sum_{i=1}^{n} t_{ci} \cdot C_i}{\sum_{i=1}^{n} t_{ci} \cdot C_i+\sum_{j=n+1}^{n+m} t_{cj} \cdot C_j} \qquad (5)$$

$$\text{Pull: } \frac{\sum_{j=n+1}^{n+m} t_{cj} \cdot C_j}{\sum_{i=1}^{n} t_{ci} \cdot C_i+\sum_{j=n+1}^{n+m} t_{cj} \cdot C_j} \qquad (6)$$

C_i and C_j represent machine cost only, and there are further expenses to be considered. The cost of storage – in this case, Holding Cost *(HC)* -, is added to this (see Eq. (7) and Eq. (8)), where *RM* stands for raw material and *FG* stands for finished goods:

$$\text{Push: } \frac{HC+\sum_{i=1}^{n} t_{ci} \cdot C_i}{HC_{RM}+\sum_{i=1}^{n} t_{ci} \cdot C_i+\sum_{j=n+1}^{n+m} t_{cj} \cdot C_j} \qquad (7)$$

$$\text{Pull: } \frac{\sum_{j=n+1}^{n+m} t_{cj} \cdot C_j}{HC_{FG}+\sum_{i=1}^{n} t_{ci} \cdot C_i+\sum_{j=n+1}^{n+m} t_{cj} \cdot C_j} \qquad (8)$$

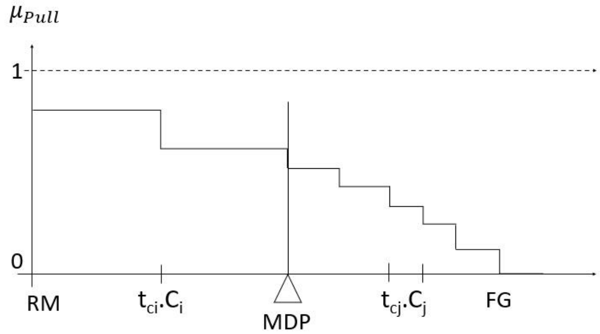

Fig.5. Fuzzy membership function of pull being calculated by (8)

If it contains HC_{RM}, it shows that the product is more of a Push product, since the Pull product is made for a specific period based on customer demand. So, the higher the *HC*, the more the system can be considered Push.

Important remark: Despite an apparently full pull system at first glance, when finished goods are stored for different reasons, for example, to consolidate the cargo and save cost in the delivery phase, in (Eq.8) HC_{FG} is not zero, the maximum value cannot reach *1*, and the sum of membership values of being push and being pull is also less than *1*. In this case, type2 fuzzy sets have to be applied that can describe the double uncertainty of the phenomena (see Fig. 5.).

The presented system of fuzzy representation is vital since - as it is demonstrated- even relatively simple situations can be very confusing and mislead the management. The proposed method can be used to objectively determine which logistic strategy is required for a given product, thus reducing the effect of Overconfidence bias in the process of decision-making.

The problem is well illustrated by the mask shortage that occurred during the COVID-19 pandemic. Mask production was a push system before the COVID-19 pandemic. A forecast was used to determine when and how many masks would be sold, and these forecast quantities were produced and then sold. With the onset of the COVID-19 pandemic, the forecast, based on decades of experience, was wiped out. Suddenly, production became a pull system, because when the raw material came in, they already knew which customer the particular quantity of masks they were producing belonged to. This publication demonstrates that the choice between Push and Pull systems is very confusing at times, as there are times when the Push logistics system is the right one, and then, in response to an unexpected situation, the product requires a Pull logistics system.

Accordingly, the system of equations described above can determine, for a given product or the company as a whole, whether the production uses a Push or Pull logistics strategy. Consequently, the decision-influencing effects of cognitive biases in the choice of logistics strategies can be avoided.

VI. Summary

Logistics is a frenetic field, one of the characteristics of which is frequent decision-making during the work process, accompanied all too often by time pressure. The importance of the logistics field was also brought to the fore by the COVID pandemic when most of society realized that if logistics systems do not work well, then the "supply of the world" does not work either. The disruption of supply chains also "overruled" the use of the previously popular Just In Time system, so the importance of choosing logistics strategies also increased.

This paper first presented an analysis of Push and Pull logistics systems and sustainability in terms of published papers. Despite the importance of addressing the impact of logistics strategies on sustainability, it was found that there are relatively few publications on the subject. After describing the emergence of cognitive biases, the 5 main categories of cognitive biases were introduced in corporate decision-making. For each main category, an example appearing in a logistics specialty was added to clarify the appearance of the types of corporate decision-making in the course of logistics decision-making. After describing the antecedents and history of the development of logistics strategies, the cognitive biases that appear during the choice between Push and Pull systems are illustrated through a concrete example. To clarify the choice between the Push and Pull strategy, three case studies were presented as well as a system of mathematical equations that support decision-making related to logistics strategies and help avoid the appearance of cognitive biases.

VII. Conclusion

This publication points out that the cognitive biases that appear during logistics decision-making have a significant impact on the formation of the logistics environment and logistics processes, so their influence on decisions cannot be ignored.

In the field of logistics, sustainability is first and foremost a strategic choice. Inappropriate logistics subprocesses damage the environment through the purchase of unnecessary equipment, parts, or packaging. If logistics strategies are not internally coherent, this, in turn, has an impact on sustainability. Cognitive biases occur during the decision-making process in the internal coherence of logistics strategies. Furthermore, the system may become unsustainable if an inappropriate logistic strategy is chosen because of cognitive bias. Therefore, it is also of paramount importance to avoid the appearance of cognitive biases in the decision-making process of logistics strategies to achieve sustainability.

The most important task of logistics strategy is to strengthen, coordinate and manage the relationship between corporate strategy and the logistics function, so that logistics can actively contribute to the company's performance and success. In this publication, only the Push and Pull logistics strategy was dealt with, which may seem simple, but if the right strategy is not chosen, it will not be sustainable.

Often Pull is chosen because it is fashionable and people think that keeping high stock is inappropriate. Assuming everything could be managed in Push and Pull, does not weigh the choice between strategies appropriately. However, if the Pull strategy is chosen unnecessarily, it can lead to high environmental impact, transport costs, pollution, and congestion in traffic areas.

It may be commercially worthwhile for a company because the external costs are not factored into the business model; society pays the cost, but it is not sustainable. In the short term, it seems right, but in the long term, it causes significant damage.

In order to give a proper description of the actual situation and help the decision-making, quantified measures have to be applied, and the fuzzy membership functions are capable of handling the issue. To develop the equation system, a sequential production line was first visualized, and then the workstations for the Push and Pull systems were defined. The membership values of the "Pull" state were calculated with different accuracies depending on the characteristics of the production. In order to estimate the "Pull" status, cycle times, workstation costs and storage costs had to be taken into account. The system of equations developed was used to convert the result into a type2 fuzzy number.

The proposed system of fuzzy indicators based on technical and objective data supports decision-making between logistics strategies by mitigating cognitive biases.

The presented and discussed set of fuzzy indicators based on technical and objective data are able to point out the real nature of the outlined production system from logistics point of view. The actual values of the calculated type2 fuzzy numbers are representation of the practical operation, so cognitive biases can be considered, which is extremely important in the logistics field, where the decisions have to be made partly on the basis of subjective, vague or uncertain parameters.

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Péter Földesi PhD was born in Budapest, Hungary in 1962. He graduated from the Budapest University of Technology and Economics as a Transport Engineer in 1986 and obtained PhD degree at the Hungarian Academy of Sciences in 1994. He worked for a large international haulage company as a marketing consultant in 1990, then joined the academic staff of Budapest University of Technology and Economics. In 1995 he moved to Győr (Hungary). He took a position at the Széchenyi István University, at the Department of Logistics and Forwarding, where he was promoted to Head of the Department in 2007. He was the Rector of the University between 2013 and 2021.

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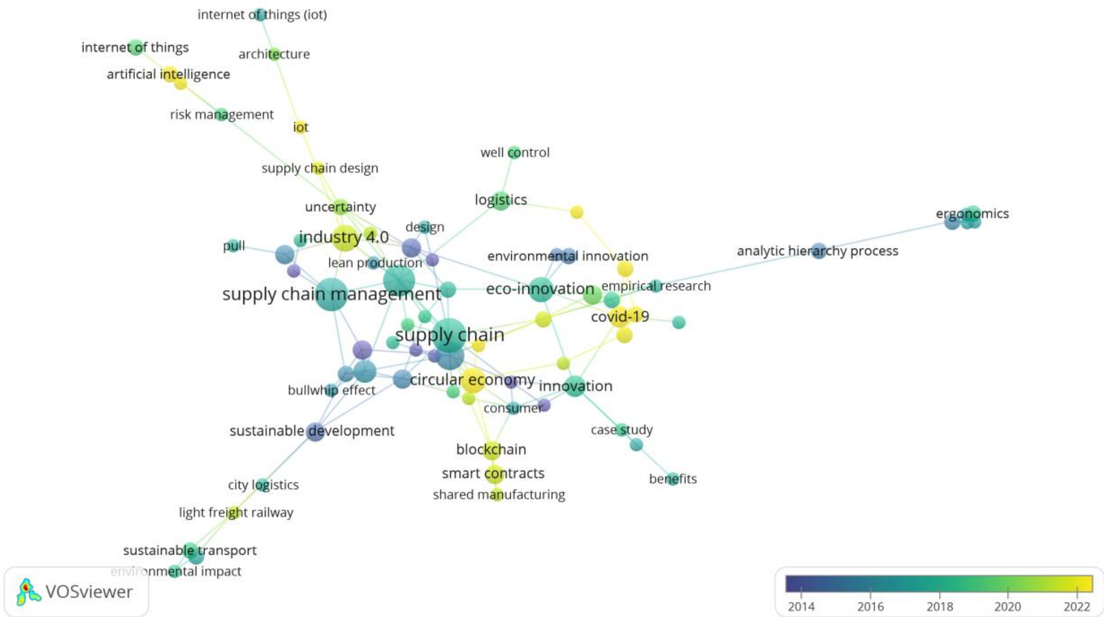
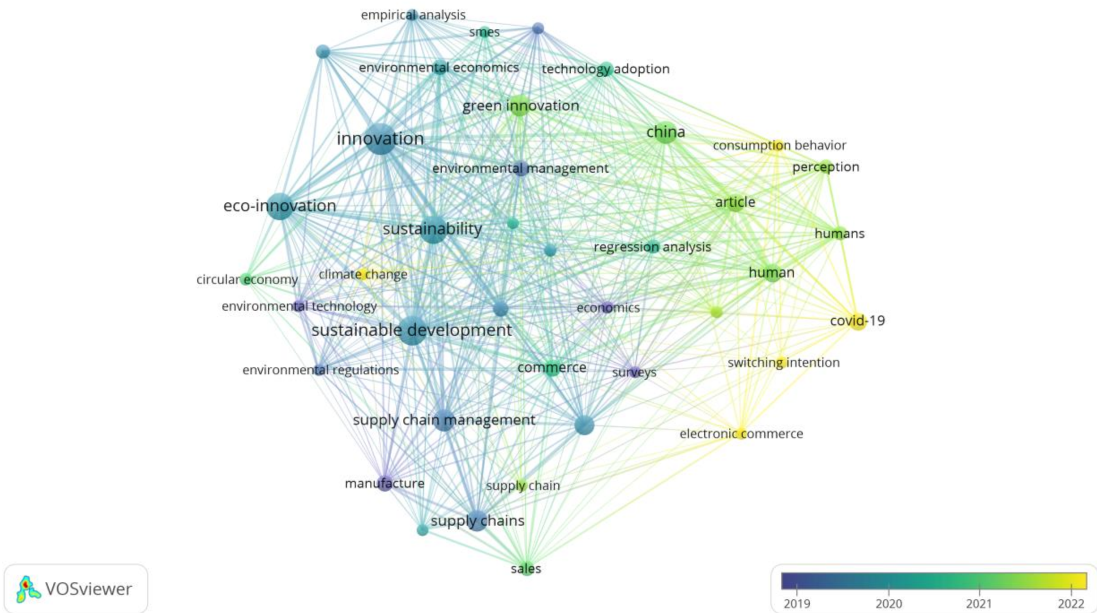
APPENDIX 1



OVERLAY VISUALIZATION BY VOSVIEWER FROM THE RESEARCH RESULTS OF SCIENCEDIRECT ON THE 10TH OF APRIL 2024. KEYWORDS: "PUSH PULL" AND (LOGISTICS OR "SUPPLY CHAIN MANAGEMENT") AND SUSTAINABILITY. THE MINIMUM NUMBER OF OCCURRENCES OF A KEYWORD: 2.

APPENDIX 2



OVERLAY VISUALIZATION BY VOSVIEWER FROM THE RESEARCH RESULTS OF SCOPUS ON THE 10TH OF APRIL 2024. KEYWORDS: "PUSH PULL" AND (LOGISTICS OR "SUPPLY CHAIN MANAGEMENT") AND SUSTAINABILITY. THE MINIMUM NUMBER OF OCCURRENCES OF A KEYWORD: 20.

APPENDIX 3

Types of cognitive biases	Pattern recognition biases	Storytelling trap	Instinctively searching for information that provides justification to support a situation.
		Confirmation bias	Searching for corroborating information about pre-existing views, e.g. policy. Ignoring information that contradicts our point of view.
		Champion bias	The company trusts a well-performing professional more, even if the information is objectively not relevant.
		Experience bias	To make a decision based on memory and experience in an environment where these experiences are no longer applicable.
		Attribution error	Success (or failure) is attributed to a single person in the company. E.g. Steve Jobs, Apple
		Halo effect	Adopting the best practices of a successful person in the hope that the strategy they use will work.
		Survivorship bias	Only the strategies of successful leaders are studied. There are several lessons to be learned from studying failed companies.
	Action-oriented biases	Overconfidence	To overestimate one's abilities, which affects the decisions made.
		Planning fallacy	Excessively optimistic planning, regarding budget and time.
		Overprecision	To overestimate our ability to predict the future.
		Competitor neglect	Underestimating competitors, ignoring the competition
	Cognitive inertia	Anchoring	The leader tends to use the numbers presented to him as an "anchor" even if that number is not relevant to the case. For example, an annual budget plan.
		Commitment escalation	Because of a promise, they won't change the already established strategy so that the energy invested until then "doesn't go to waste"
		Status quo bias	Avoiding difficult decisions, therefore maintaining the status quo.
		Loss aversion	Loss aversion is one of the biggest barriers to development.
		Uncertainly aversion	Avoiding unknown risk in order to avoid loss.
		Hindsight bias	They judge the same occurrence with different probability before and after the event has occurred.
	Self-Interest biases	Present bias	The company's management does not think long-term. Immediate benefits instead of future profits.
		Self-serving bias	Individuals are driven by an unconscious intention to make decisions for their own self-interest, whether financial or emotional.
		Omission bias	The management of the company accepts when someone else makes a mistake and not themselves. In addition, they consider it morally acceptable to profit from it.
	Group biases	Groupthink	People tend to adopt the collective point of view even when they know it is not correct.
		Information cascades	The order of speakers distorts the outcome, as the opinions of those who speak first are amplified.
		Polarization	As a result of groupthink, the group's opinion will be more extreme, which the group members will represent more confidently. It also deepens commitment.