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Sustainable Logistics Management in the 21st Century Requires Wholeness Systems Thinking

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Abstract: The 21st century is characterised by the unprecedented speed and scope of changes, creating a new external environment, where the logistics systems are managed. The latest development in logistics management is influenced by sustainability, which complements the economic dimension with environmental and social dimensions. The fundamental principle of logistics management is systems thinking (ST). Until now, the reductionism ST (RST), focusing on the maximal economic performance of a logistics system's parts and interactions has been applied. However, the RST approach does not sufficiently consider the implication of the external environment to the economic performance. The article's aim is the introduction of the new wholeness ST (WST) approach and confirmation of its fundamental role in deriving of the performance of the selected logistics system's parts and interactions from the external environment. WST's role was demonstrated in a case study, comparing the WST and RST approach in management of particular automotive logistics' system. The WST approach in the management of the whole selected logistics system assures a considerable reduction in the consumption of resources. Based on the comparative case study's results, the conceptual framework for the application of the WST approach in all sustainable dimensions is proposed.

Keywords: sustainable logistics management; wholeness systems thinking; lean management; logistics system

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1. Introduction

The first decades of 21st century are defined by the unprecedented speed and scope of changes (e.g., customer satisfaction in terms of demanded product complexity, product delivery lead time, and requirements of stakeholders in environmental and social aspects). In addition to the changes, the importance of uncertainty and risks resulting from the changes has been increasing dramatically.

Thanks to these changes, logistics management (LM) must adopt new managerial concepts. One of the recent leading concepts in the business sphere is sustainability, which complements the economic dimension with environmental and social dimensions. Application of the sustainability theory in LM has led to a new concept—sustainable logistics management (SLM).

The system theory is the crucial methodological approach applied in LM [1–3]. Any system consists of parts, interactions and purposes [4]. The current systems thinking approach identified in LM has been defined for the purpose of the paper as the reductionism systems thinking (RST) approach (see Section 4.1). It replaces the previous reductionism. Reductionism expected that the optimal performance of the collection of parts could be attained by maximising the performance of each individual part. RST defines the system as the sum of the parts and interactions creating the system's purpose, which attains additional qualities beyond the parts themselves [5,6]. The system's performance, defined by RST, is the maximised performance of its parts and interactions. According to the three years of research presented in Section 3.1, RST assumptions result in over-performance of the whole defined system. Such over-performance is caused by insufficient consideration of the external environment for the performance of the defined system's parts and interactions, resulting in consumption of a useless amount of resources from the whole selected system perspective. The three-year research project identified the research gap in systems thinking and led to the definition of the new Wholeness Systems Thinking (WST) approach. The WST approach identifies the new role of a system's purpose, deriving the performance of the selected system's parts and interactions. Furthermore, the WST approach defines the properties of the selected system's purpose as derived from the superior system (external environment), which the selected system is a part of.

The article's aim is the introduction of the new WST approach and confirmation of the significant role of the external environment in deriving the logistics system's purpose, which is further responsible for defining the sustainable performance of a logistics system's parts and interactions. Supporting the article's main aim, three sub-aims are defined. The first defines the new WST approach in general and in comparison with previous approaches and in the context of the economic dimension of SLM. It states that, the system's purpose is defined by the external environment and afterwards derives the optimal performance of the studied logistics system's parts and interactions. The second aim proves that WST, in comparison to RST, leads to the optimal economic performance in managing a particular logistics system. The third and final aim is to propose the conceptual framework (CF) for the application of the WST approach in all sustainable dimensions of SLM.

2. Literature Research

2.1. Theoretical Background

In this section, the current state of knowledge in the systems thinking, LM, logistics system, sustainable development (SD) and SLM is reviewed. Systems thinking has roots in General System Theory (GST) [7]. Its goal is the formulation and derivation of these principles that are valid for systems in general. They are of a physical, biological or sociological nature. It could be called the general science of the whole. In modern science, GST presents the focus on interactions of the parts of the system creating the whole, replacing the previous era of Descartes' scientific reductionism focused on the analysis of the properties of the parts creating the whole. After the introduction of GST in the 1950s, the main focus of systems thinking development was oriented on cybernetics or technical systems [8]. The sociological part of the systems thinking development has become relevant starting in the 1990s [9]. Interactions between the parts creating the whole systems are the corner stone of the systemic thinking used in social sciences that understands synthesis as a tool to create the whole, after taking the system apart through analysis. The original systemic thinking describes the analysis as the disassembly of the whole into individual parts, and the synthesis as the composition of the individual parts into the functional whole [10]. However, this approach systematically eliminates the role of the surrounding environment—the superior system. Especially nowadays, when everything changes at an unpredictable speed and the only certainty we have about the future is that it will be different, this is a significantly limiting factor. Ackoff discussed that synthesis and analysis are both essential, complementary aspects of systems thinking. Systems thinking consists of analysis and synthesis. Analysis focuses on structure. It reveals how things work. Synthesis focuses on function which reveals why things operate as they do. It does not mean that synthesis is more valuable than analysis. It means that they are complementary. Analysis looks into the system; synthesis looks outward to consider the systems environment. Both views assessing the system's understanding and development have the same importance [11].

The study is also based on the following definitions of LM and logistics systems and the interrelationship of these terms. LM plans, implements and controls the efficient and effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements. Actually, LM is considered part of SCM. SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all other LM activities. It includes all of the LM activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology [12]. One of the key parts of LM and SCM is the flow of the resources needed to satisfy customer requirements, which is subject to the order fulfilment process (OFP). An adequate OFP needs to be implemented cross-functionally with the coordination of key suppliers and customers [13].

Flow of the resources between the point of origin and the point of consumption requires interconnection of at least two or more parts. The definition of a system that is a set of two or more elements is as follows: the behaviour of each part has an effect on the behaviour of the whole; the behaviour of the elements and their effects on the whole are interdependent; elements of a system are so interconnected that their independent subgroups cannot be formed [14]. In fact, LM is planning, implementing and controlling a logistics system consisting of at least two interacting parts influencing the properties of the whole system and vice versa [15]. The logistics system deals with the flow of orders, transformed into deliveries within and across the companies. Part of the logistics system that links the company (e.g., producer) with suppliers is called inbound logistics and the company with customers is called outbound logistics. Transformation of the final or semi-final customer orders into their deliveries is the flow consuming resources.

In the past few decades, LM and SCM incorporate spheres of SD [16]. SD was introduced in "Our Common Future" report (Brundtland Report) by the World Commission on Environment and Development (Brundtland Commission) in 1987 [17]. The Brundtland Report defined SD as "[the] development that meets the needs of the present without compromising the ability of future generations to meet their own needs" and presented three dimensions of sustainability: economic growth, environmental protection, and social equality. This concept has been further developed by Elkington in 1998 as the Triple Bottom Line (TBL) concept [18]. TBL attempts to treat all three dimensions of sustainability with equal importance and thus could be considered an integrative theory of sustainability [19]. These studies of sustainability refer to the macro-economic perspective. For the purpose of the research, the authors of the paper apply a micro-economic viewpoint defined by the management literature. The most respected definition of business sustainability is by Sikdar [20]: "a wise balance among economic development, environmental stewardship, and social equity".

Definitions of SLM are based on the combination of sustainable theory and LM. Given this fact, SLM can be defined as "a resource management process that combines SD with a logistics system; SLM offers companies economic, environmental and social benefits, such as an increase in asset utilization, enhanced customer service, increased energy efficiency, reduced impact on the community, and improved quality of life." [15]. Today, SLM is considered an integral part of sustainable supply chain management (SSCM) [21–23]. From this point of view, SLM can be defined as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of SD, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements" [24].

2.2. Development of Systems Thinking in LM and SLM

Before the 1990s, the business environment was characterised by a reductionist way of thinking, disassembling the whole business into individual parts, strategic business units (SBU) and maximising its performance. Reductionism succeeded in increasing the efficiency of production processes and, from the 1960s in the US, also logistics processes. Production and logistics shortages were transformed into significant surpluses (ability to produce and deliver more than the expectations of final customers). The supply exceeded demand and businesses started to improve their efficiency by internal integration [25]. During the 1990s, new technologies such as EDI or integrated software solutions (MRP and ERP) enabled the improvement of not only separated parts, but also their interactions [26]. It was the era of the wide distribution of internal and external integration in LM and the beginning of Supply Chain Management (SCM), which could be understood as the start of systems thinking's application in this sphere [27]. Reductionism was replaced by systems thinking, which is defined for the paper's purpose as the RST approach. RST defines the system as the sum of the parts and interactions, making the system's purpose more valuable than just the previous reductionism. It understands the business as a collection of the parts (SBUs) and their interactions. The purpose of RST is to maximise the profit (minimise the unit costs) by increasing the performance of parts and their interactions. The meaning of the RST approach could be compared to holism or the holistic approach as well. However, holism or the holistic approach is understood more as focusing on the interactions of parts, creating the bigger whole, than just the collection of the parts. Another description is that the parts of the whole are in intimate interconnection, such that they cannot exist independently of the whole or cannot be understood without reference to the whole, which is greater than the sum of its parts [4–6]. Moreover, holism and the holistic approach lacks the systematic and methodical consideration of the external environment, a deficiency in the systems thinking approaches.

The LM in SCM context, especially the Lean, Agile, Resilient, and Green (LARG) SCM concept, describes the strong correlation between changing conditions in the business environment and the aspiration of the academic sphere to develop new and efficient SCM, including LM attitudes [28–30]. Christopher argues for a change in the logic of SCM because of the enormous variability and increasing turbulence [31] and utilisation of a customer-oriented principle through the implementation of the pull principle, not only between a customer and the marketing department of the final producer, but even in all the previous chains and processes [32]. The whole purpose of LM is to provide customers with the level and quality of services that they require, and to do so at the lowest possible total LM cost [33].

Given the fluctuations in the market from globalisation and the expectations of the demanding customer, real production volumes change dramatically, and forecasting is less and less accurate. The uncertainty and risks resulting from the external environment are affecting the optimal performance of systems parts and interactions in a significant way [34,35]. After almost 30 years of innovations, which could be described by the RST approach, serious surpluses in the performance of a logistics' system parts and interactions are still identified. The RST approach does not sufficiently take account of today's unprecedented speed and scope of changes in a turbulent business environment. Figure 1 depicts the development of systems thinking connected with the development of market conditions during the last decades. The described logistics system is defined from the supplier to the customer, i.e., it consists of the supplier, producer and customer of the system elements. Reductionism explains that produced quantities exceeded demanded quantities because of particular improvements in LM elements. Over-performance of separated elements is caused by increasing particular productivity. RST explains that the improvement in over-performance was made by internal and external integration of the logistics system (e.g., by EDI, MRP, ERP and SCM systems), including forecasting of the final customer orders. Nevertheless, the over-performance, caused by particular improvements and partial consideration of customers' requirements by forecasting of the orders in a dramatically changing external environment, is still significant. The authors of the article argue that it is caused by the current RST approach, which is unable to explain systematically the importance of the external environment, i.e., real customers' expectations, for the optimal performance of selected logistics system's parts and interactions. Furthermore, it could be the reason for the discussion about the application of systems thinking among academics [36,37].

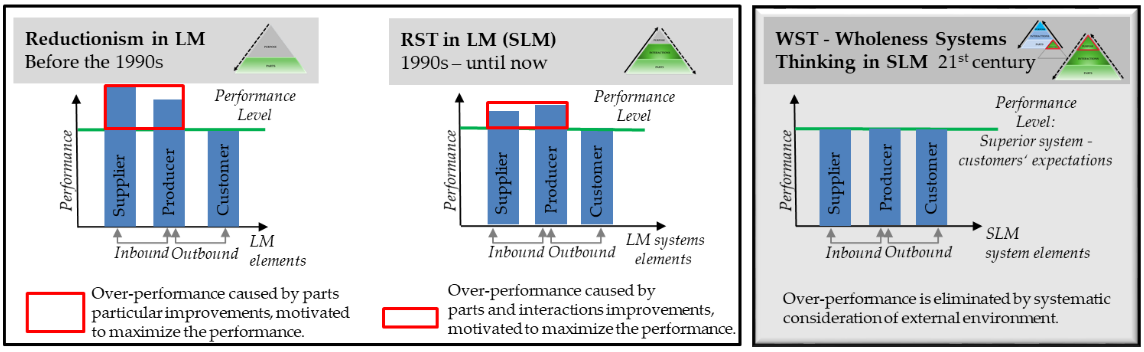

Figure 1. Development of the reductionism and systems thinking approaches connected with LM and SLM elements performance.

Sustainability began to be of interest to LM and SCM researchers at the start of the second decade of the 21st century, which has resulted in the development of SLM and SSCM concepts [38]. Its application was extended from the original economics performance to the environmental impact and community quality of life [39]. The current RST approach considers three dimensions of SD separately, which is argued between the scientists [40] and results in over-performance, i.e., over-consumption of resources from the wholeness perspective. Performance derived by the external environment/customer expectations, implemented in the selected system's parts and interactions by the system's purpose, eliminates over-performance and assures considerable savings of resources in the whole logistics system. The optimal performance is to produce what is expected (not less, not more), i.e., what the customer is willing to pay for. Therefore, the smooth flow of real customer orders transformed into the deliveries through the whole integrated logistics system creates reasonable limits for economics performance of its particular parts and interactions.

For that reason, the authors of the article proposed a new systems thinking approach—WST, which defines methodically the relation of a system's elements, especially that between the system's purpose and the significant role of superior systems, representing the external environment. The WST approach contributions, i.e., explaining and underscoring the importance of the superior system's and the external environment created by customers' expectations in the economic dimension of sustainability, are demonstrated by a comparative case study of the current RST and proposed WST approaches. Based on the case study's results, the CF proposes the application of the WST approach in other dimensions of sustainability in LM.

3. Materials and Methods

The article's main aim is the introduction of the new WST approach and the confirmation of the significant role of the external environment for deriving the logistics system's purpose, which is further responsible for defining the optimal sustainable performance of logistics systems' parts and interactions. The article's main aim is supported by three sub-aims, which are briefly introduced with their methods of achievement in this chapter.

3.1. Sub-Aim 1: WST Approach Introduction and Definition

The important role of the external environment, superior system, in performance of the selected system's parts and interactions was revealed during the three-year research project, completed by the authors at SKODA AUTO University in 2017. The project studied several practical case studies and performed critical a literature review from systems thinking, sustainability, automotive logistics and supply chain management. The practical application of the current RST approach in systems thinking identified that it cannot adequately describe and systematically apply the importance of the external environment, represented by the superior system for optimal, sustainable performance of a system's parts and interactions. The important role of the external environment, superior system, in deriving of the system's purpose for the optimal performance of system parts and interactions started to be studied [41–44]. The application of the current RST system approach during researching the project contains a serious level of over-performance, consuming an unnecessary amount of resources [45,46]. Thus, the role of the external environment, creating the reasonable borders for the elimination of ever-present over-performance in studied logistics and supply chains systems, needed to be systematically defined and verified. Kolb's theory of learning style [47], which combines inductive and deductive methods in researching new knowledge and understanding, was used during the development of the new WST approach. In the inductive part, the new role of analysis, synthesis and system's purpose was identified by reflective observation during the research project. The abstract conceptualisation enabled the definition the RST approach and the WST approach (see Section 4). The proposed WST approach was compared with the actual RST approach in a case study in the deductive part (see Section 5).

3.2. Sub-Aim 2: Comparison of RST and WST Approaches in the Economic Dimension of SLM

To achieve the second sub-aim, a case study that compared the RST and WST approaches in a particular automotive logistics system was chosen as the main research method. According to Yin [48], case studies can be divided into three categories: exploratory, descriptive and explanatory. To verify the benefits of the WST approach, the exploratory case study was used since the WST approach, which was being investigated, was a new phenomenon. The WST approach was verified on the economic dimension of sustainability (see Section 5).

In the case study, Integrated Kanban System (IKS) was used as a tool for visualising and evaluating the ability to manage a selected logistics system with respect to a superior system, i.e., customer orders. IKS helped to visualise the quantity of resources needed to produce the same quantity of products during the application of the RST and WST approaches. In this manner, the case study allowed for a comparison of the traditional RST approach describing the logistics systems management by focusing on analytical improvements of system parts and interactions and the new WST approach considering the influence of the external environment (customer requirements), which had a significant impact on the performance and consumption of resources of the whole logistics system, including its parts and interactions.

IKS is an e-kanban system for production, LM and SCM [49]. It is a real-time connection of external suppliers and customers by recording the movement of each single kanban, which enables the implementation of a complete kanban pull system in the whole logistics system. IKS kanban flow is made by scanning the kanban cards via barcode readers or RFID chips. Continuous visualisation identifies the precise quantity of kanbans in scheduling, Work in process (WIP), finished goods, transported goods and customer stock triggered by real consumption (see Table 1).

Table 1. Visualisation of kanban localisation in the IKS logistics system.

Supplier	WIP	Supplier work in progress waiting for completion
	Finished goods (FG)	Number of finished goods in distribution stock of supplier
	Transported goods	Number of finished goods in transport
Customer	Customer stock (CS)	Number of finished goods in material stock of customer

The kanban system depends on the number of containers circulating in the kanban loop. The fixed level of stock and quantity of containers at each stage in a logistics system is calculated based on concrete circumstances. There are three kanban levels to be balanced in the IKS, production lot size level, safety stock level and minimum stock level. Customer stock and transported goods are covered by the minimum stock level, preventing the interruption of customer production and fluctuation. The safety stock level contains the maximum number of kanbans at WIP and finished goods serviced by the supplier. The production lot size level contains the optimal production quantity from the supplier.

The total amount of containers in the logistics system kanban loop is the sum of the previously mentioned three levels.

Traditional MRP/ERP solutions offer static and fragmented data, updated by rigid time cycles. IKS offers dynamic online visualisation of real production and logistics performance between external partners, which improves integration of the whole logistics system. IKS integrates real customer requirements and enables improvements of productions and logistics processes in the whole logistics system (see Table 2).

Table 2. MRP/ERP and IKS visibility difference of real customer consumption.

IKS Visibility of Real Customer Consumption		MRP/ERP Visibility, Forecasting Data	
Supplier	WIP	**Supplier**	WIP
	Finished goods (FG)		Finished goods (FG)
	Transported goods		Transported goods
Customer	Customer stock (CS)	**Customer**	Forecasting of real consumption
	Integration based on real visibility of customer consumption		Integration based on forecasting of customer consumption

3.3. Sub-Aim 3: Proposal of the CF of WST Approach Application in SLM

Based on the achievement of previous sub-aims, the proposed CF defines key variables, sustainable superior systems and the sustainable external environment represented by sustainable dimensions and visualises their relationships with the studied logistics system through the verified WST approach. Key assumptions, principles and benefits assuring the optimal wholeness performance of a selected system from the perspective of all sustainable dimensions are described in Section 6.

4. WST Approach Introduction and Definition

4.1. WST Approach Definition in General

Systems thinking is a perspective of seeing and understanding systems as wholes rather than as collections of parts. Systems behaviour is present when the system is operating as one; it is not merely the sum of the individual components. Systems thinking is a methodical approach to understanding problematic situations and identifying solutions to these problems [14]. Systems thinking helps to organise studied system elements to reach a desired purpose. Systems thinking consists of parts, interactions and purpose (4). The systems thinking elements could be visualised as a pyramid hierarchy, which is critical for further comparison of current and proposed systems thinking approaches. The pyramid hierarchy describes a certain order of system elements (parts, interactions, and purpose). A system consists of at least two interacting parts. The system purpose is the one which none of its parts have. Any part of the system influences directly or indirectly the system purpose and the system purpose influences every part or interaction of the system. The mutual relation between system elements is critical for the performance of the system as a whole [11]. The important role of the external environment in assessing the system in the systems thinking was already discussed [9,11]. Nevertheless, the systematic definition of the role, structure and mutual interactions of a system's elements and the external environment considering the system's performance as a whole has not been proposed yet. Wholeness is defined as the state of forming a complete and harmonious whole, a unity in other words. Therefore, the proposed ST approach, defining the relation between the system's elements and implementing the role of the superior system/external environment for the performance of the system's elements (purpose, parts, and interactions) and the system as the whole is defined as WST.

The new understanding of the role and importance of purpose in a system's pyramid hierarchy is defined by the Wholeness Synthesis (WS) and Wholeness Analysis (WA) (see Figure 2). The current general understanding of analysis is taking a system apart and synthesis is putting the parts together to create the whole system. It eliminates the important influence of the external environment, superior system, on the performance of the system's elements (parts, interactions, and purpose).

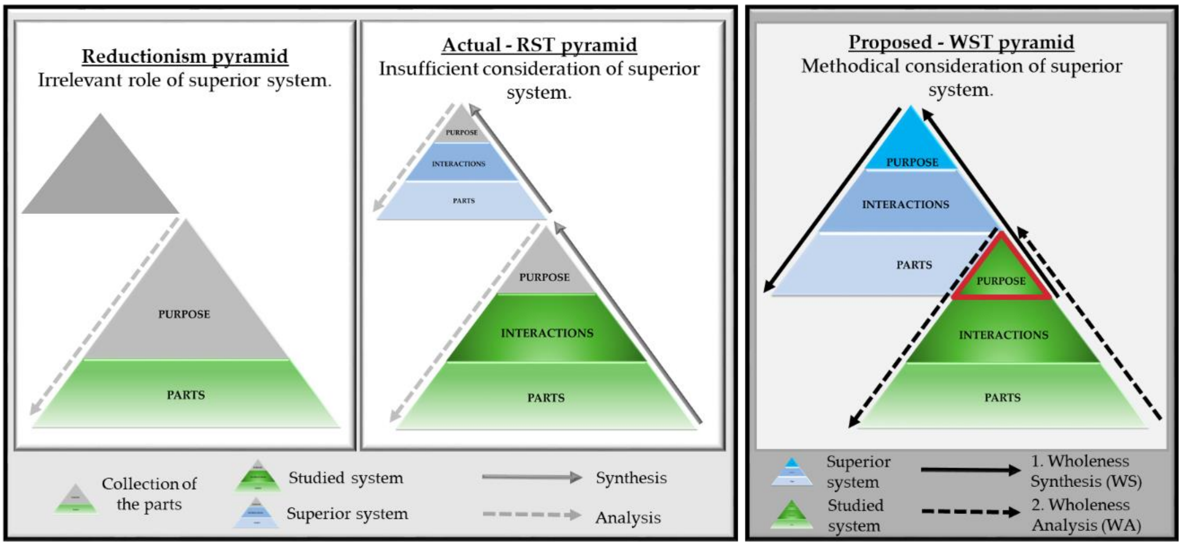

Figure 2. Development of the system's purpose role in considering external environment represented by a superior system in reductionism and systems thinking pyramid hierarchy.

The system purpose is the system element responsible for the performance of system parts and interactions, considering the important role of the external environment. WS synthesises the system purpose from the superior system perspective. The performance of a system's purpose is derived from the superior system and is defined in three steps:

1. Identifying the superior system,
2. Understanding the superior system,
3. Identifying the purpose of the studied system in the superior system.

The third step of WS interconnects the influence of external environment, superior system, into the performance of studied system purpose. WA breaks a system down into elements (parts, and interactions) from a system purpose perspective (the purpose was already defined as WS). The WA is defined also in three steps:

1. Taking a studied system apart (parts, and interactions) from the purpose perspective (as defined by WS).
2. Understanding each part taken separately.
3. Aggregating understanding of the parts and interactions into understanding of the whole system.

The first step assures the system purpose perspective and interconnection with the external environment (see the third step of WS). The crucial contribution of the WST approach is an understanding of the fundamental role of the studied system purpose, synthesised from the external environment—superior system, for specifying the optimal performance of parts and interactions in the studied system. It systematically enables the prevention of system over-performance (see Figures 1 and 2). The development of the role of a system's purpose in the systems thinking pyramid is described as follows:

- Reductionism—the purpose is the sum of the parts. (The collection of parts is analysed from the individual parts perspective into individual parts; the parts are motivated to maximise the performance; the better the performance of the parts, the better the performance of the whole.)

- RST—the purpose is the sum of the parts and interactions. (The whole system is analysed from the perspective of individual parts into individual parts and interactions; the parts and interactions are motivated to maximise the performance; the parts and interactions are synthesised into the best possible performance of the whole system.)
- WST—the purpose of the whole system is synthesised from the superior system (representing the external environment) perspective through WS; it creates limits for the performance of studied system parts and interactions; the purpose is analysed by WA into the performance of the system's parts and interactions.

Given the serious changes in the external environment, the systematic identification of the studied system's purpose in the superior system, representing the external environment, is responsible for optimal performance and consumption of resources of studied system's parts and interactions. The WST approach application in systems understanding and development consists of three steps:

1. Identification of the studied and superior systems,
2. WS of the studied system purpose in the superior system,
3. WA of the studied system purpose into the studied system parts and interactions.

The fundamental role of a system's purpose is the basis of the difference between the current RST and the new WST approach in understanding and assessing the systems. Thus, the new systems thinking definition that takes into account the important role of the external environment due to the new role of the system's purpose is needed. Based on the presented assumptions, the WST approach can be defined as follows: understanding and assessment of the whole system, consisting of parts, interactions and a purpose, which requires the WS of the studied system purpose from the superior system perspective, and the WA of the studied system into parts and interactions from the perspective of the studied system's purpose. The synthesised system purpose interconnects systematically the superior system, representing the external environment, with the studied system and expresses the active role in defining performance of the studied system's elements (parts and interactions).

4.2. WST Approach Application in the Economic Dimension of SLM

The application of the WST approach in the visualisation of system's pyramid is depicted in Figure 3. The pyramid includes the new important role of the studied system's purposes and WS and WA in the economic dimension of SLM, which consists of 4 elements (customer, producer, and two suppliers). The three steps of the WST approach application are applied. The first step is identification of the studied (suppliers and producer) and superior (producer and customer) systems. The second step is WS of the studied system (suppliers and producer) purposes in the superior system (customer and producer). The third step is WA of studied system purposes (suppliers and producer) into the studied system parts and interactions. The systematic application of the WST approach in the economic dimension of sustainability explains the important role of the customer in the subsequent phase of the OFP transforming the orders into deliveries. A defined logistics system consists of the logistics system's parts (suppliers, producer, and customer) and their interactions managing the flow of the orders transformed into the deliveries from the point of origin to the point of consumption. The customer represents the superior system (external environment) deriving the purpose of the studied systems, which is responsible for performance of the studied system elements.

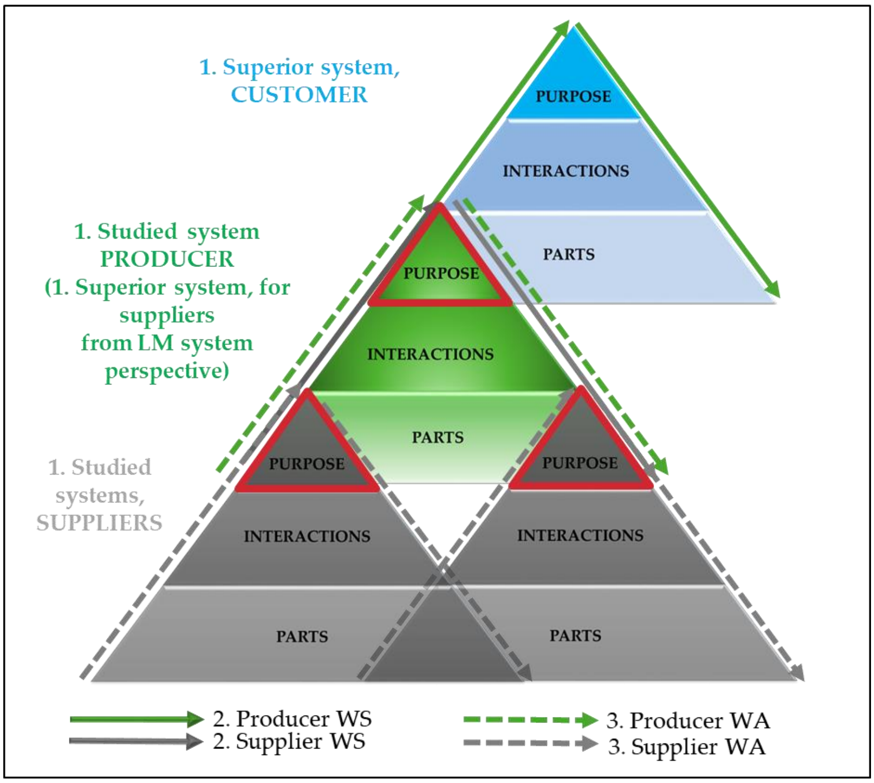

Figure 3. Three steps of the WST approach application in a defined logistics system.

Previous systems thinking approaches did not express and systematically describe the important role of the system's purpose, derived from the external environment for performance of a logistics system's parts and interactions.

The reductionist and systems thinking approaches define different purposes (see the previous subchapter). This difference can be illustrated in the economic dimension of SLM: Reductionism describes the purpose of businesses as the sum of maximum profits of defined logistics systems parts (suppliers, producers, and customers). Reductionism analyses the particular parts with its concrete departments and motivates them to reach maximum profit and minimum unit costs, without consideration of interactions with other parts of a logistics system. Particular improvements of parts, without consideration of interactions and purpose, were responsible for a serious amount of over-performance resulting in significant consumption of resources. RST's purpose is created by the sum of maximum profits (minimum unit costs) of the analysed particular parts and their interactions in a logistics system. The purpose consists of analysing the performance of parts and their interactions and synthesising them into the maximum performance of the whole logistics system. The importance of RST's purpose for systematic elimination of over-performance is passive. The customer requirements representing the superior systems are not directly deriving the performance of the logistics system's parts and interactions. The superior system is represented by forecasted volumes of customer orders in general, which better organises and plans the existing performance of the logistics system's parts and interactions than the previous reductionism. The role of the superior system/external environment in assessing the studied system is already considered. Nevertheless, it is used inadequately for deriving the performance of a logistics system's parts and interactions, which does not allow for considerable reduction or elimination of over-performance. Therefore, it is considered an inadequate reflection of the external environment. The systematic consideration of the superior system is proposed by the WST approach. WST's purpose of the studied system is synthesised by the WS from the superior system, concrete customer expectations expressed by real orders. The studied system's purpose is broken down by WA into the performance of parts and its interactions directly derived from the customer requirements. The logistics system's parts and interactions directly adjust their performance according to the real requirements of the external environment (in comparison with previous forecasted requirements), which is considered an optimal performance resulting in reasonable consumption of resources.

For the superior systems defined in the environmental and social dimensions of SLM, the roles of the studied system's purpose, WS, and WA are proposed to be applied analogically in Section 6.

5. Comparative Case Study of the RST and WST Approaches in the Economic Dimension of SLM

The WST approach benefits were verified in the comparative case study of the automotive logistics system. Logistics systems in automotive generally consist of a large number of participants (1000 s of first-tier suppliers, second-tier suppliers and third-tier suppliers, which are interconnected by numerous forwarders and logistics services providers). The feasibility of a complex logistics system within the comparative case study requires its simplification.

5.1. Logistics System Description

The selected logistics system consisted of 125 suppliers (delivering 6000 components), a producer (manufacturing 640 components) and 32 customers. From an automotive perspective, it means there were 125 third-tier suppliers, 1 second-tier supplier and 32 first-tier suppliers in this system. The simplified logistics system studied in the comparative case study consisted of 2 suppliers (third-tier suppliers), 1 producer (second-tier supplier) and 1 customer (first-tier supplier) presented in Figure 4. Within the simplified logistics system, the product portfolio was simplified as well. The producer produced only one product, consisting of two components, which were supplied by two of the suppliers.

Although the whole automotive logistics system was not included, the verification of the WST approach contributions is possible. System simplification results in identifying the repeating patterns in studying systems [50]. The simplification of the logistics system used in the case study means identifying the similar system elements (parts, interactions and purpose, which could be identified either at the studied, simplified logistics system or in the whole automotive logistics system) and their patterns and characteristics and studying them in a mutual context, including the role of the external environment. These patterns or characteristics are identified either in the whole system or in the simplified system. The same wholeness qualities, which are essential for the studied structure, are identified. The WST approach application explains the difference between reductionism and simplification. A simplified logistics system, applied in the case study, was managed with the respect to the WST system's purpose or, if applicable, the external environment and their mutual context, which has the same pattern and characteristics as in the whole automotive logistics system.

The presented case study compares different quantities of resources needed for fulfilling the same quantity of customer orders. The comparison is made between the traditional RST approach utilising MRP/ERP systems to optimise resources capacity and logistics flows, and the new WST approach based on the kanban (pull) principle and other lean tools implemented for logistics flows and resources planning and control. These systems, in general, include strategical, tactical, and operational planning levels. The level included in the case study is an operational one, which manages the flow of the orders and its transformation into deliveries.

RST encourages the logistics system elements and interactions (with the help of the forecasting of the customer orders) to maximise the performance of the whole system. The pull principle corresponds to the WST approach. This approach understands the logistics system as a system dependent on the superior system, where customer (the first-tier and second-tier suppliers) requirements determine the optimal performance of the logistics system's elements and interactions of the producer and suppliers (the second- and third-tier suppliers production and delivery processes). The WST approach motivates the logistics system's elements and interactions to adjust flexibly its performance based on the real consumption of resources by customer and the producer (the first- and second-tier suppliers) (see Figure 4).

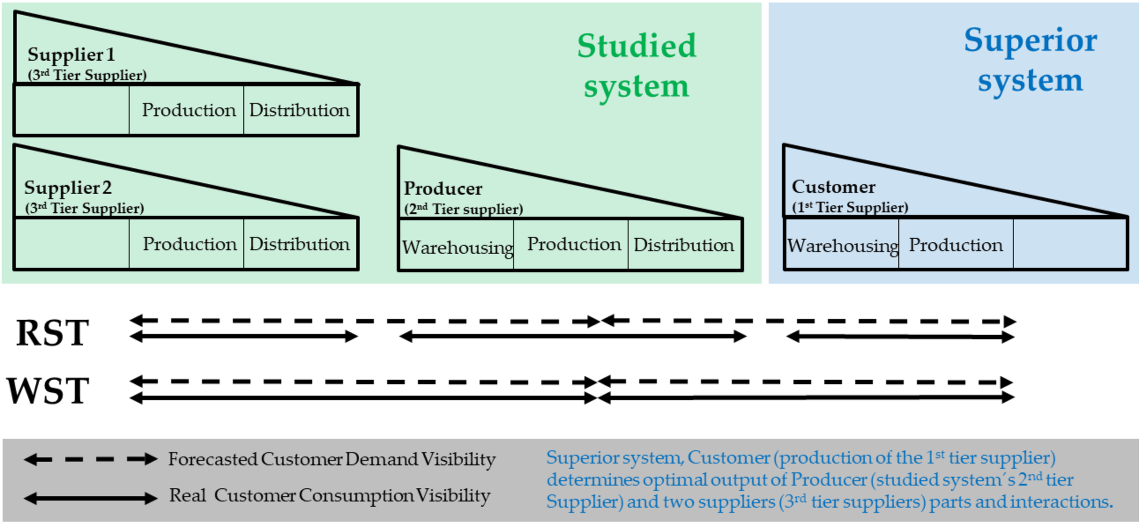

Figure 4. Case study logistics system structure comparing the RST and WST approaches in SLM.

The comparison of both approaches was made over 52 working days. Given the comparability of case study results (there were different ordered quantities during the testing period), an adjustment of trends influencing the ordered quantities was made.

RST and WST performance was measured by KPIs. Commonly used KPIs in LM addressing the economic dimension of sustainability are inventory costs, logistics costs per unit, labour efficiency, utilisation of capacities, process cycle time, flexibility of production, etc. [51]. These KPIs motivated the studied logistics system's parts and interactions to reach minimum unit costs without consideration of the superior system, external environment (see the RST purpose in Section 4.2). The WST approach required appropriate KPIs, enabling it to measure the contributions resulting from consideration of the external environment to the optimal performance of the studied system's purpose, parts, and interactions (see the WST purpose in Section 4.2). The KPIs measuring the studied logistics system's performance were the total lead time and total stock level. These KPIs are able to express the wholeness contributions of the WST approach because they represent the role of the logistics system's purpose of customer satisfaction. It replaced the former RST purpose, maximum profit, minimum unit costs of a logistics system's parts, and interactions. The wholeness perspective measurement supposes the ability to measure and compare the optimal performance of the whole process within and across the companies included in the studied logistics system. The comparisons of WST and RST approaches can be evaluated according to other indicators that respect the wholeness sustainable system thinking approach, but for the purposes of the article, the selection of the two indicators is sufficient.

5.2. RST Planning Principles

The RST SLM works with forecasting of the orders. Based on forecasted information, the particular logistics system elements plan the maximum performance (warehousing, production, and distribution). The production processes of all of the logistics system's elements are managed by classical ERP software maximising the utilisation of all considered elements and interactions. Production is organised according to production efficiency in high-volume batches, without considering the customer requirements (only forecasted customer requirements are considered). Each part of the logistics system is managed and optimised separately according to the forecasted volumes. The forecasted production volume is distributed in the whole logistics system every week (7 working days). The people responsible for organising the flow of the orders (buyers at the producer and the customer) see static data about only their particular production sites at the end of the week (actual warehouse level of components and finished goods, forecasted production for next week, production capacity, and number of components in transportation).

The production processes in the logistics system were described by the demanded quantities (pieces, and containers), container lot sizes, production lot sizes, and delivery times (see Table 3). Production was managed by forecasted production volumes at each stage of the logistics system. The RST purpose, maximising the performance of particular logistics system elements led to certain characteristics of RST SLM: fluctuation in demand, unlevelled production, including in-balance human resources, once-a-week delivery, unstable dispatch and delivery times, quality issues, maximising production lot sizes, container volumes, and delivery frequency. Fluctuations in demand were the source of serious waste (thanks to the well-known bullwhip effect). The studied logistics system hardly followed the customer expectation changes and trends, which built slow moving and obsolete inventory in each of the logistics system's elements. There was a list of internal and external negative influences on the real flow of the orders and deliveries. Internal sources were quality of finished goods, availability of components, human and production resources, influence of salesmen, etc., while external sources can be described by quality and quantity of components, containers, failures of transportation, etc.

The RST SLM planning principles are described by a traditional understanding of analysis, taking a system apart (warehousing, production, and distribution), maximising the performance of parts and interactions and synthesis, summarising the parts and interactions together to create the whole system. The role of the external environment was inadequately considered by forecasted customer requirements, which did not derive the performance of studied logistics system's parts and interactions (parts and interactions were still motivated to maximise its performance, which was afterwards fulfilling the customers' requirements). Therefore, the whole system performance depended on the performance of the system's parts and interactions, without direct consideration of the external environment, resulting in the over-performance of the whole system.

Table 3. Case study of RST planning details.

Supplier 1		**Producer**	
Container lot size (pcs)	450	Container lot size (pcs)	270
Minimal production lot size (pcs)	450	Minimal production lot size (pcs)	5400
Delivery time (days)	5	Delivery time (days)	10
Supplier 2		**Customer Requirements**	
Container lot size (pcs)	1000	Delivery quantity (containers)	20–40
Minimal production lot size (pcs)	5000	Delivery frequency	once per week
Delivery time (days)	5		

5.3. WST Planning Principles

After the WST approach implementation (pull principle, IKS, lean tools, etc.), the SLM works with the real flow of the orders and real consumption of resources within and across the logistics system (customer, producer and suppliers). The particular logistics system's elements (warehousing, production, distribution, etc.) plan their optimal performance according to the real situation at each stage of the logistics system from its customer's perspective, which prevents higher or lower performance of all the system's elements. The case study's WST planning details are presented in Table 4. The WST SLM planning principles are described by the WST approach, including a new understanding of synthesis (WS) and analysis (WA). WS defines the superior system expectations, which are represented by new customer orders. WA systematically implements these expectations into the performance of the logistics system elements (warehousing, production and distribution). Such an attitude assures the customer satisfaction (characterised by flexibility, quality and availability) requiring the optimal consumption of resources. There are three steps in the WST approach application (see Figure 3):

1. Identification of the studied and superior systems. The customer is the superior system of the producer. The producer is the studied system and superior system of the suppliers. The suppliers are studied systems.
2. WS of the studied system's purpose in the superior system:

    - Identification of the superior system: customer and producer.
    - Understanding of the superior system: customer produces and delivers the components to the Original Equipment Manufacturer (OEM), which requires frequent deliveries of high-complexity products. These products are assembled from hundreds of components. Following the OEM requirements, the customer expects high-quality products with reliable delivery services.
    - Identification of the purpose of the studied system in the superior system: based on the understanding of the customer's requirements, the producer needs to assure the expected product and delivery services.

The same is applied identically for the producer as a superior system and suppliers as studied systems.

3. WA of the studied system's purpose into the studied system's parts and interactions:

    - Analysis ofthe system (producer warehousing, production, and distribution) from the perspective of the studied system's purpose (defined by WS).
    - Definition of the performance of parts and interactions according to the customer's expectation and perspective. The optimal performance of the studied system's parts is not maximum performance (minimum unit costs) but the performance required by the superior system, i.e., the customer (delivery quantity and frequency per day; see Table 4).
    - Aggregation of the performance of parts and interactions defined by the customer's perspective, which creates the efficient flow of the resources through the entire studied system process, i.e., the producer.

The same is applied identically for the two suppliers.

Table 4. Case study of WST planning details.

Supplier 1		**Producer**	
Container lot size (pcs)	450	Container lot size (pcs)	270
Minimal production lot size (pcs)	450	Minimal production lot size (pcs)	5400
Delivery time (days)	2	Delivery time (days)	10
Maximum number of containers at supplier	14	Maximum number of containers at customer	11
Maximum number of containers at customer	10		
Supplier 2		**Customer Requirements**	
Container lot size (pcs)	1000	Delivery quantity (containers)	2–8
Minimal production lot size (pcs)	2000	Delivery frequency	once per day
Delivery time (days)	2		
Maximum number of containers at supplier	7		
Maximum number of containers at customer	5		

5.4. Case Study Results

The IKS system enables comparison of the traditional RST approach and innovative WST approach in SLM by means of two KPIs, the total lead time and the total stock level.

5.4.1. Lead Times Results

The lead time of a particular logistics system's elements is the sum of their individual times (processing time, holding time of finished goods, transporting time and holding time in the customer stock). The lead time of the entire logistics system is given by the sum of supplier 2's lead time (higher than supplier 1's lead time) and the producer's lead time.

The whole structure of lead times can be seen in Table 5. The total lead time of WST SLM was reduced by 49.7% in comparison with the total lead time of RST SLM.

Table 5. Lead times in the studied logistics system.

SLM element	Time	Average Amount of Days Spent in RST SLM	Average Amount of Days Spent in WST SLM
Supplier 1	Processing time	3.0	1.1 (−65.1%)
	Holding time of FG	3.1	4.4 (41.9%)
	Transporting time	1.0	0.9 (−10.0%)
	Holding time in CS	5.8	3.0 (−48.3%)
	Lead time	12.9	9.4 (−27.1%)
Supplier 2	Processing time	3.5	1.7 (−51.4%)
	Holding time of FG	4.1	2.0 (−51.2%)
	Transporting time	0.9	1.0 (11.1%)
	Holding time in CS	6.0	1.5 (−75.0%)
	Lead time	14.5	6.2 (−57.2%)
Producer	Processing time	3.1	1.7 (−45.2%)
	Holding time of FG	2.6	2.4 (−7.7%)
	Transporting time	3.8	1.0 (−73.7%)
	Holding time in CS	8.0	1.6 (−80.0%)
	Lead time	17.5	6.7 (−61.7%)
Whole examined part of SLM	Lead time	32.0	16.1 (−49.7%)

The WST SLM approach, including WS and WA, explains, in scholarly terms, the influence of lean management tools and the principles to reduce the total lead time by 49.7% in the whole studied automotive logistics system, producing the same number of products that satisfy the customer. The significant time-savings were possible due to the application of the new way of systems thinking within and across the studied logistics system participants. The specific application of the WST approach needs to be organised properly not only at the operational level of the studied logistics system activities to complete the long-term perspective's expectations.

Qualitative benefits were not part of the case study; however, experience from day-to-day operations identified the following positive aspects of the WST approach during the ongoing case study:

1. Cooperative atmosphere with simultaneous control of inventory of all the participants enables the creation of standardised expectable processes.
2. Increased stability in the production cycle in terms of run timing and volume enables better assumption for optimal planning of capacity and resources.
3. Freeing up the resources to focus on improving processes and relationship rather than just trouble-shooting.
4. The WST approach's operations are smooth, instead of common stress, occurring in the RST execution.
5. In WST, the producer and suppliers can access customer inventory situation any time, without waiting for orders. Urgent orders, which are common for RST, disappear.

5.4.2. Stock Level Results

The total quantity of containers in the studied system represents the success of integration and the whole economic effect of the pull principle and lean tools' implementation. It also represents the reasonable costs needed for the production required by the customer. The IKS system visualises the quantity of containers in a graphical form (see Figures 5–7). The blue column represents the quantity of containers in the customer stock. The yellow column shows the transported quantity. The turquoise column represents the finished goods in the supplier stock. Finally, the grey column represents suppliers WIP quantity of containers. The red dash curve in the WST approach represents the minimum stock level, the yellow dash curve represents the safety stock level, and the green dash curve represents the production lot size level (see Section 3.2).

RST SLM results for supplier 1: The flow of the orders from the producer and material flow was managed by the ERP/MRP system (accumulating the customer requirements into large-order lot sizes). The previously mentioned planning principles led to the results described in the left subfigure of Figure 5. Partial optimisation of production and logistics processes supported by this prediction led to fluctuations in the total quantity of containers in the whole system. The main source of fluctuations was the customer's stock changes. Every day, the total quantity of containers ranged from 31 to 64.

WST SLM results for supplier 1: Elimination of production fluctuation, real-time visibility of the flow, execution by end operators, increase of delivery velocity, standardisation and other lean tools and principles led to a stable, everyday total quantity of containers with ranges from 20 to 23 (see the right subfigure of Figure 5). There is room for possible improvements in the quantity of the safety stock level, which means the quantity of containers was reduced by the same level as that for supplier 2 (see Figure 6).

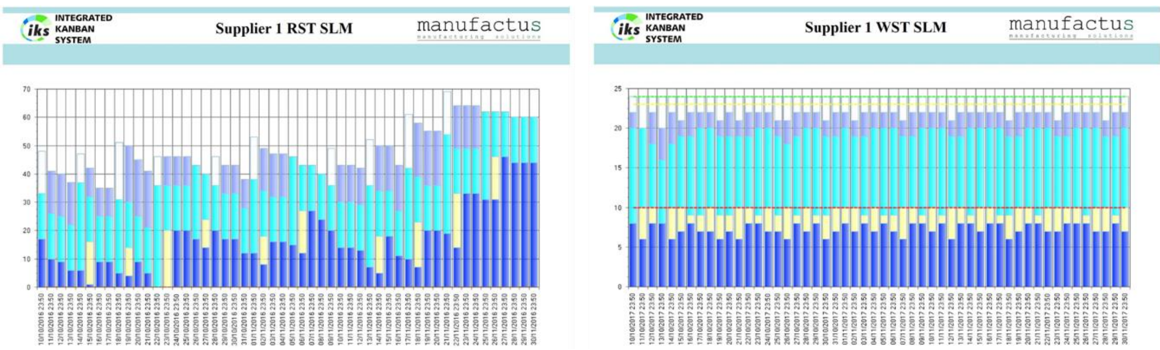

Figure 5. Quantities of container units in RST SLM and WST SLM for supplier 1.

RST SLM results for supplier 2: the ERP/MRP system was well managed until the producer demand slowed down in the middle of the period. The ordering frequency was longer with smaller quantities due to the designed phase-out and the Customer demand was partially fulfilled by newly designed part replacement. This unexpected change has also heavily impacted the supplier finished goods stock and obligation. The quantity of containers ranged from 22 to 53 (see the left subfigure of Figure 6).

WST SLM results for supplier 2: Mutual lean tools' and principles' implementation, including minimisation of production lot size and increasing delivery frequency, has impacted the producer's stock and supplier's finished goods stock. It supported maximal flexibility and minimal risk of obsolete inventory. The quantity of containers ranged from 10 to 12 (see the right subfigure of Figure 6).

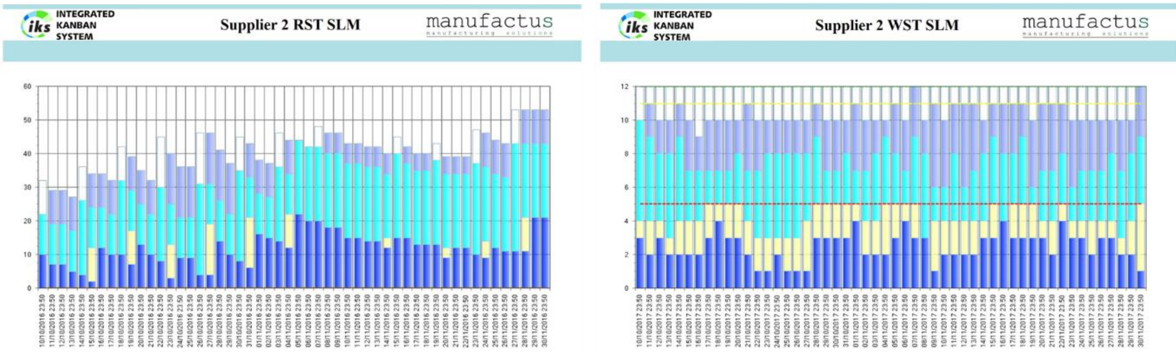

Figure 6. Quantities of containers in RST SLM and WST SLM for supplier 2.

RST SLM results for the producer: The producer was expecting the impact of high demand because of the customer sales campaign in the first one-third of the period. In the middle one-third period, the customer sales were average, and the stock was consumed smoothly without replenishment. In the last one-third period, the customer advised a schedule of two-day production maintenance and placed a large order to the producer to cover this period. The quantity of containers ranged from 49 to 102 (see the left subfigure of Figure 7).

WST SLM results for the producer: The customer kept a higher standard of inventory level which was fulfilled by the producer for the flexible support of the customer's demand, including sales campaigns and preventive maintenance of the customer. The quantity of containers ranged from 19 to 27 (see the right subfigure of Figure 7).

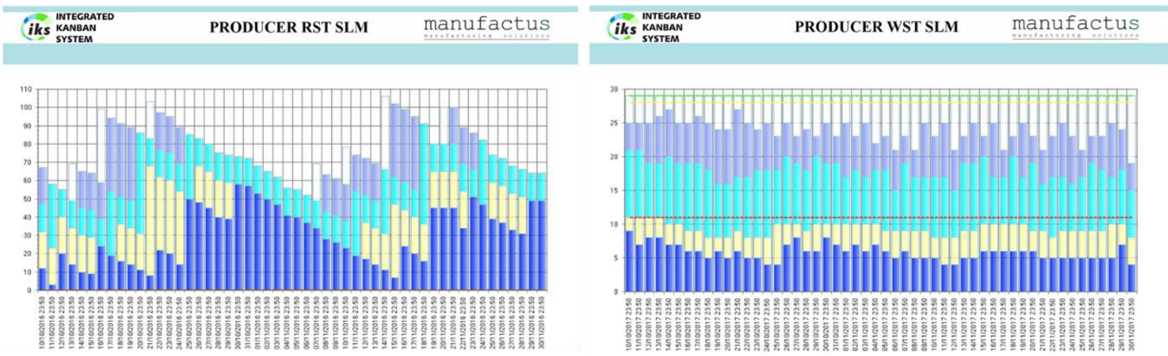

Figure 7. Quantities of containers in RST SLM and WST SLM for the producer.

Figures 5–7 illustrate results of the pull principle and lean tools' implementation in the particular logistics system elements. The total effect in the whole studied logistics system is shown in Table 6. The average quantities of containers during the whole tested period are shown. The total number of containers in the whole examined logistics system decreased by 65.1%, which was three time smaller in the WST SLM in comparison with the RST SLM. The clear influence of the consideration of the external environment/superior system was identified. Due to the application of the WST approach including WS, WA and the role of the system's purpose in the definition of optimal performance of the production and logistics processes of the customer, producer and the suppliers systems enables the serious reduction of containers and resource consumption in terms of the components' availability for the production of the same quantity of outputs. The suppliers and the producer benefited from the intensive cooperation with its customers (the producer and the customer) and reached significant savings in consumption of resources connected with the flow of containers quantities in the studied logistics system, which can be observed in Table 6.

Table 6. Stock level in the studied logistics systems.

SLM Element	Stock	Average Amount of RST SLM Containers	Average Amount of WST SLM Containers
Supplier 1	WIP	8.3	2.3 (−72.3%)
	Finished goods (FG)	18.8	9.8 (−47.9%)
	Transported goods	2.8	2.3 (−17.9%)
	Customer stock (CS)	16.4	7.3 (−55.5%)
	Total amount	46.3	21.7 (−53.1%)
Supplier 2	WIP	6.8	2.7 (−60.3%)
	Finished goods (FG)	18.8	3.4 (−81.9%)
	Transported goods	1.7	1.7 (0.0%)
	Customer stock (CS)	11.6	2.5 (−78.4%)
	Total amount	38.9	10.3 (−73.5%)
Producer	WIP	10.8	5.8 (−46.3%)
	Finished goods (FG)	18.8	8.6 (−54.3%)
	Transported goods	14.6	3.5 (−76.0%)
	Customer stock (CS)	30.1	5.8 (−80.7%)
	Total amount	74.3	23.7 (-68.1%)
Whole examined part of SLM	Total amount	159.5	55.7 (−65.1%)

The 52-working-day case study enables the comparison of the different systems thinking approaches influencing the quantity of components needed for the same output of the defined logistics system. The significant difference in performance (expressed by the quantity of components needed for the same customer requirements) of studied logistics systems elements (WIP, finished goods, transported goods, and customer stock) between maximal performance (RST SLM approach) and performance derived from the superior system (WST SLM approach) is visible in the percentage changes of the average amount of containers of each logistics system's parts and interactions in brackets (see Table 6). Online visibility of real superior system requirements, resulting in better responses to customer requirements and levelled production volumes, enables decreases in the quantity of containers in the WIP of the logistics system by 72.3% for supplier 1, 60.3% for supplier 2 and 46.3% for the producer. Flexible management of resources, standardization, and predictability of daily activities enabled the reductions of the containers quantity in finished goods by 47.9% for supplier 1, 81.9% for supplier 2 and 54.3% for the producer. A newly released regular transportation time-schedule and shift to the delivery of mixed loads of different components to more points of consumption has enabled reductions of containers in transported volumes by 17.9% for supplier 1 and 76% for the producer. Reduction of shortages, elimination of mistakes, immediate solving of quality issues and the ability to see and adjust the lot sizes of production and delivery reduced the over-performance of the further processes and resulted in the reductions of 55.5% for supplier 1, 78.4% for supplier 2 and 80.7% for the producer containers needed in the customer stock.

Structured evaluation of the RST and WST approach comparison in the studied logistics system explained and demonstrated the significant savings of resources and quantity of containers needed for the same logistics system's output. The transition of the meaning of the system's purpose from maximal performance of logistics system parts and interaction to a performance defined by a superior system, i.e., the external environment, leads to the concrete, quantified results, which are visible from the wholeness perspective due to the total stock level KPI, able to clarify and compare total consumption of resources in the whole studied logistics system, rather than particular consumption or resources in the particular parts and interactions of the logistics system. The concrete changes dramatically improving the wholeness performance, such as online visibility of customer requirements, levelled the production volumes. Flexible management of resources, standardisation, regular transportation time-schedule, delivery of mixed loads of components to more points of consumption, reduction of shortages, elimination of mistakes, immediate problems-solving as well as adaptability of production and delivery lot sizes results from the application of different purposes of the logistics system. The WST approach explaining the presented concrete changes had a similar level of effect to the second wholeness KPI, the total lead time (see Table 5). The RST purpose, sum of the maximised performance of parts and interactions resulting in minimised unit costs (consumption of resources), causes the over-performance visible in the wholeness perspective. The minimised unit costs of each part of the logistics system measured by traditional KPI's (inventory costs, logistics costs per unit, labour efficiency, utilisation of capacities, and process cycle time) prevents the application of previous wholeness changes because it could cause an enhancement of particular costs. The operational level of SLM should be managed by the WST purpose, considering customers' real consumption needs representing the external environment, in order to derive performance of the selected system's parts and interactions and eliminate their inefficient performance from the wholeness perspective.

5.5. General Case Study Contributions

The RST approach could be explained as a "producing more" attitude. Increases in produced quantity, and maximum particular performance cause minimum unit costs of particular elements and their interactions in the logistics system. Minimum unit costs prioritise exploitation of available capacities and technologies. The wholeness picture enables a view that such an attitude causes over-performance, overproduction consuming a serious amount of resources in the logistics system as the whole. However, the purpose of the logistics system, studied from the superior system, is not maximal performance of parts and interactions (warehousing, production, and distribution) generating maximum profit, but maximal satisfaction of the customer's expectations (following the real customers' orders). The WST approach could be explained as a "consuming less" attitude. Reduction of consumed resources through the elimination of the over-performance (of parts and interactions by considering the role of the dramatically changing external environment) could result in higher particular unit costs of parts and interactions in some cases, but the total consumption of resources in the whole logistics system is significantly less. The main reason is the wholeness perspective enabling an evaluation of current activities and its meaningfulness from the superior system, i.e., customers' requirements expectations (system purpose), not out of maximising performance of parts and interactions. The WST approach presents the systematic change in a system's purpose, which could be understood as the innovation in effectiveness (doing the right things), not the change in the efficiency of a system's parts and interactions (doing things right).

The crucial role of the external environment implemented by a system's purpose in the optimal performances of logistics system's parts was verified in the economic dimension of SLM. The 65% reduction of total stock level and 50% reduction in total lead time reduction represent the positive benefits of the WST approach. The significant impact of the WST approach application could be expected in the environmental and social dimension, which will be proposed by the CF in Section 6.

5.6. Case Study Limitations

The following limitations of the study have been identified. The verification of the study is processed on the operational level of simplified automotive logistics system, in order to sufficiently visualise the specific WST approach benefits in comparison with the previous RST approach. Nevertheless, the crucial assumption of successful implementation and complete exploitation of the expected contributions in the whole SLM, in the long-term perspective, is the application of the WST approach in all the logistics system activities at the tactical and strategical level as well. Concretely, actually used MRP solutions for tactical and strategical planning (e.g., long-term resources planning, machine capacity or shift pattern) needs to start considering the role of the external environment (WST approach) because of the significant reduction of total resources consumption. For example, the WST approach should be applied during the planning of the final or semi-final new products' complexity (caused by material, technological or design requirements), levelling of serial production (called heijunka in lean terminology), etc. The authors of the research focus on the forward flow in logistics' system. However, there are several other approaches investigated in the literature, such as resilient, reverse, closed-loop or circular flow.

6. CF of WST Application in all Dimensions of SLM

Based on the results of previous research, the aim of the CF is to define the assumptions, principles and benefits of the application of the tested WST approach in all dimensions of sustainability in SLM. SLM offers companies economic, environmental and social benefits, such as an increase in asset utilisation, enhanced customer service, increased energy efficiency, reduced impact on the community and improved quality of life [52]. A sustainable logistics system focuses on logistics operations (e.g., supplier selection, procurement, manufacturing, warehousing and delivery), in order to reduce a company's costs, lessen its environmental impact and address the impact it has on society [15]. SLM is the system enabling a company to maximise the profitability, minimise the environmental impact and improve the community's quality of life [39]. Actual application of SD in SLM is characterised by the RST approach or, if applicable, the RST purpose definition (see Section 4.1) focusing on maximising of the system elements' performance in order to get the best possible performance of the whole system from a three-dimensional perspective.

The application of SD in LM is facing two major challenges. The currently used RST approach does not lead to the optimal performance of a logistics system as a whole, which was verified in economic dimension of SLM by the case study. At the same time, it is argued that the separation of the sustainability concept into three pillars is the reductionism approach, which tends to emphasise potentially competing interests instead of focusing on the linkages and interdependencies between pillars [40], which is not optimal from the wholeness perspective as well. The aim of the proposed CF is to solve the first problem: how to identify purposes of three separated sustainable dimensions and improve the performance of SLM's elements in order to reduce consumption of total SLM resources. The proposed CF does not solve the second problem, the identification of the one sustainable dimension integrating the previous three, which could be further transferred by the WST approach into the performance of SLM's elements. The future research, balancing the interactions of three sustainable pillars (applying the WST approach to identify the superior system expectation), needs to be carried out.

Based on the definition of the WST approach (see Section 4.1) and sustainability literature research, three principles for applying the WST approach in all dimensions of SLM (see Figure 8) could be identified:

1. The selected system's purposes are defined by superior systems (external environment), which are in the case of SLM represented by three sustainable dimensions: economic, e.g., customer's requirements represented by orders; natural environment, e.g., environmental requirements represented by United Nations (UN); social, e.g., society requirements represented by employees and authorities.
2. The superior systems, representing the external environment of an SLM system are created by stakeholders (customers, employees, community groups, authorities, Non-governmental organizations (NGOs), etc.). In an earlier approach, the individual stakeholders focused on their goals within the framework of individual sustainable dimensions. At present, stakeholders' requirements are intertwined with each dimension. Customers are no longer focused on just economic goals related to price and customer service, but they are required to meet the goals related to other dimensions of sustainability (natural environment and social responsibility). Satisfaction of economic requirements in terms of price, quality, availability, etc., are complemented by environmental requirements in the field of green logistics, for example, preferring green transport and social requirements, taking into account the principles of the fair-trade foundation, etc.

3. The wholeness KPIs need to be identified in each dimension of sustainability to measure the performance of the whole selected logistics system in particular dimensions (total lead time, carbon footprint, quality of life, etc.), enabling the visualisation of the wholeness benefits.

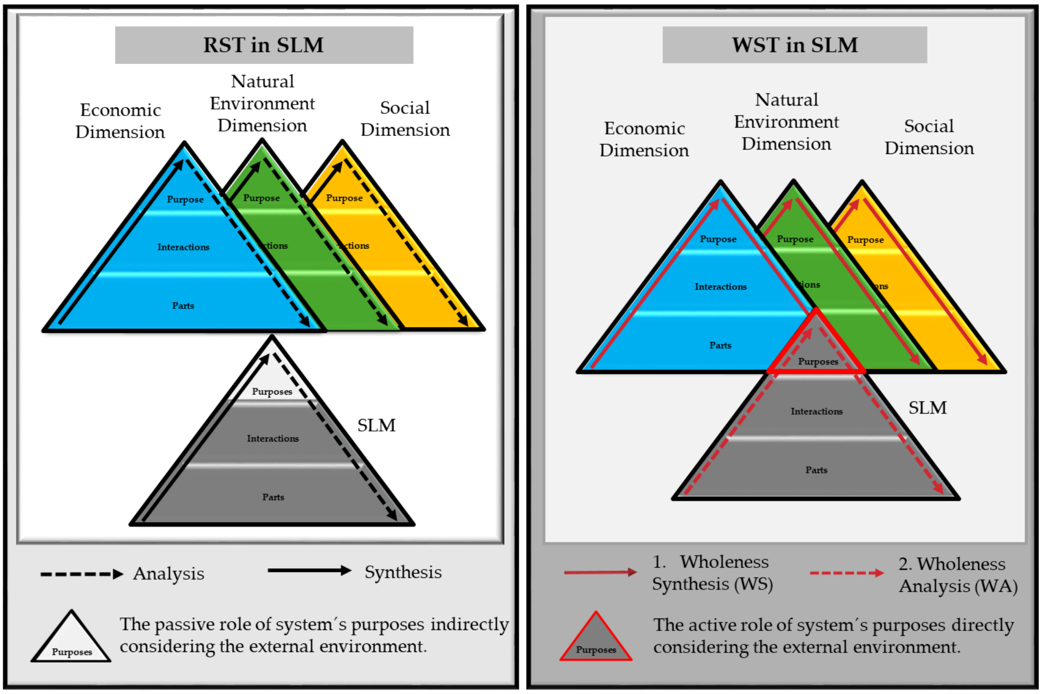

Figure 8. Conceptual Framework of the WST approach in all dimensions of SLM.

CF visualises the new role of the system's purposes in all dimensions of SLM. The passive role of the system's purposes results from the RST approach, where the purposes and requirements of the three-dimensional external environment are identified indirectly in terms of predicting of customers' requirements, general declaration of percentage reduction of environmental impact (e.g., CO^2) or quality of life improvements. The RST approach's purpose is defined as the sum of the systems' elements (parts and interactions). Furthermore, systems elements are motivated to maximise their performance without methodical consideration of the external environment.

The WST approach emphasises the active role of the system's purpose. The three steps of WS methodically define the SLM's purposes, real superior systems' requirements, representing external environment in all SLM's dimensions. The flow of real customers' orders, concretely addressing the environmental impact reduction or quality of life improvements to the system's elements, represents the real external environment requirements, which are directly transmitted by three steps of WA into the performance of the SLM's elements. Therefore, the performance of the SLM's elements consumes significantly fewer resources in fulfilling the economic, environmental and social requirements. The contributions of the active role of the system's purposes, directly deriving the performance of the system's elements, was confirmed by the comparative case study in the economic dimension of SLM.

7. Conclusions

The article studies the research gap in systems thinking. Systems thinking helps organise a studied system's elements to reach a desired purpose. The main effort of researchers in the field is dedicated to the analysis of a system's elements (parts and interactions) and their synthesis in reaching the desired purpose. The same situation was identified in the application of systems thinking in practice when researching several case studies in automotive SLM and SSCM in the presented three-year research project. Understanding a system's purpose is currently reduced as the result of the interconnections of its parts and interactions without systematic consideration of the external environment. The role of external environment for system's elements performance is considered indirectly (in economic dimensions by forecasting the customers' requirements). Therefore, the actual system's thinking approach, applied in theory and practice, was labelled as the RST approach.

The RST approach understands the system's purpose, out of the system's pyramid, as the sum of the system's parts and interactions. The RST approach replaces the previous reductionism and improves the performance of the parts through the important role of their interactions. The RST approach contains the identification of the external environment's requirements through the forecasted customer requirements in the economic dimension of sustainability. Although it improves the system's performance, it is still perceived as an inadequate consideration of the external environment. The reason is that it has not studied sufficiently the internal, mutual interdependencies of the system's elements (parts, interactions and purpose) and their relations with the external environment methodically so far. The significant role of the external environment (superior systems) for the wholeness system's performance arises in the era of unprecedented speed and scope of changes in worldwide market conditions, creating a new, demanding surrounding environment. If the system's parts and interactions are managed to perform more or less than which is required by the superior system (e.g., due to the innovation in efficiency of parts and interactions), it results in the ineffective performance of the studied system as a whole. The implication of the absent significance of the role of the external environment causes the ineffective consumption of resources of the whole selected system. Therefore, the proposed WST approach methodically interconnects the external environment represented by the superior system with the studied system through its purpose. The system's purpose considers the internal and external environment methodically through WS and WA. The new systems thinking approach was labelled as WST because it understands the system's purpose in terms of the whole, thus complementing the systematic internal part through the methodical consideration of the external environment that constitutes the meaning of wholeness of the system's purpose. The WST approach ensures that the performance of the studied system's parts and interactions is directly managed by the requirements of the superior system.

The WST approach in systems thinking is proposed in general and in the economic dimension of the SLM context. In general, the WST approach emphasises the new role of the system's purpose visualised in the systems' pyramid, which is not a passive result of the maximal performance of the studied system's parts and interactions. It emphasises the purpose's active role in deriving the system' parts and interactions performance. From the economic dimension of the SLM perspective, the RST approach defines the purpose of the studied logistics system as the sum of maximum profits (minimum unit costs) of the analysed particular parts and interactions of the logistics system. The superior system is represented by the forecasted volumes of customers' orders. Therefore, it is considered as an inadequate role for the external environment in SLM. The new system's purpose is defined by WST. The specific customer's real consumption (resulting in the new orders) creates the reasonable limits to eliminate over/under-performance of the studied system's parts and interactions. The methodical consideration of the superior system's requirements, transmitted in parts and interactions performance, results in the considerable reduction of the resources needed for fulfilment of the studied system's purpose, i.e., customers' orders in the economic dimension of SLM.

The comparative case study testing the period of the application of the RST and WST approaches was visualised in IKS. The IKS visualisation enabled the verification of the important role of the system's purpose in defining the performance of the studied logistics system's parts and interactions required by the superior system, which the selected system is a part of. A significant difference in the consumption of resources was identified (expressed by the KPI's total quantity of containers and total lead time needed for the fulfilment of the same customer requirements) in the studied logistics system's elements described in IKS as "WIP", "Finished Goods", "Transported Goods" and "Customer Stock". The methodically implemented role of the superior system through the studied system's purpose enabled significant savings of the consumed resources in satisfying the same customer requirements.

The case study's KPIs confirmed that approximately 50% of resources in terms of the total quantity of containers with the components and the total lead time could be saved. Innovation in effectiveness presented by the new system's purpose (defined by the WST approach) considers, in methodological terms, the external environment, which requires significantly fewer total resources than the RST system's purpose reached by innovation in efficiency applied to studied logistics system's parts and interactions.

The similar conclusion to that in the case study comparison can be seen from a comparison in the Volkswagen Group (VW) and Toyota Group (Toyota) management system. Toyota and VW could be characterised by the WST approach and the RST approach, respectively. These leading automotive manufactures are selling relatively comparable quantities of cars a year. Nevertheless, their wholeness productivity expressed by the operating profit margin and number of employees is significantly different (see Table 7).

Table 7. Comparison of selected data in Volkswagen Group and Toyota Group [53–57].

Data	2016		2013	
	VW	Toyota [1]	VW	Toyota [2]
Vehicle sales (thousands units)	10.4	10.2 [3]	9.7	9.9 [3]
Employees (thousands)	627	364	563	339
Operating profit margin (%)	3.3	7.2	5.9	8.9

[1] Fiscal year ended on 31 March 2017. [2] Fiscal year ended on 31 March 2014. [3] Including consolidated numbers of the whole Toyota concern (Toyota, Lexus, Daihatsu and Hino).

Profit and sales quantities of cars in VW are supported by very efficient and technologically developed particular logistics system's parts and interactions. However, maximisation of the efficiency of a particular system's elements, assuring the minimal unit costs without systematic consideration of the external environment, cannot assure the effectiveness of the whole system. On the contrary, Toyota's logistics system is rather effective, managed predominantly by the pull principle following customer satisfaction, which assures significant reduction of total costs.

Based on the successful verification of the WST approach application in the economic dimensions of SLM, the CF proposes the WST approach application in all sustainable dimensions. The WST application revealed the SLM system's purposes in general: customer's requirements in the economic dimension, environmental requirements in the environmental dimension and social requirements in the social dimension. The requirements of the superior systems identified by WS are transmitted by WA into the performance of the SLM system's elements. It implies significantly less resource consumption of the whole SLM system. The innovative system's purpose for understanding and methodical interconnection of the surrounding environment causes the significant reduction of resources in achievement of the studied logistics system's sustainable goals.

The new WST approach, methodically considering seriously changing the external environment in the 21st century assures the sustainable performance of the whole logistics system, resulting in a considerable reduction in resources' consumption.

The WST application was tested in automotive SLM. Nevertheless, the role of the external environment, influencing methodically the performance of a system's elements, is relevant in all other economic systems, e.g., supply chains performing in the 21st century business environment. The future research should identify the prudent balance between the three sustainable dimensions. The systematically defined prudently balanced Wholeness Sustainability Purpose, interconnected by the WST approach with selected SLM, brings improvements in performance setup, resulting in further reduction of resource consumption.

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case study preparation and discussion of the obtained results. V.D. prepared the IKS system description and data for the case study. D.S. and I.G. participated in the case study preparation. All authors have read and approved the final manuscript.

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