Supply Chain Research(2024) Volume 2 Issue 1
doi: 10.59429/scr.v2i1.6560

RESEARCH ARTICLE

Structure of logistics management from a computer perspective

Alexey Tyapukhin

Orenburg branch, Russian Academy of National Economy and Public Administration, Orenburg, 460000, Russian Federation

*** Corresponding author:** Alexey Tyapukhin, aptypuhin@mail.ru

ABSTRACT

In the context of digitalization, some objectives and functions of logistics management can be transferred to digital twins equipped with modern information technologies and tools. However, significant revision of theory and methodology of management is needed to maximize the potential of these technologies and tools. The problem of effective use of digital logistics management is complicated because some management objects are non-physical related to human activity and difficult to digitize and algorithmize. In this article, based on terminological analysis, as well as descriptive and faceted methods of qualitative research, following results are obtained: a typical structure of logistics management of a supply chain link is developed; the place of logistics management of a focal enterprise in three-link supply chain is determined; features of the structure of logistics management implemented at the junction of supply chain links are clarified; a typical organizational structure of logistics management division is proposed; a system of binary codes of logistics management objects has been developed for their correct transfer into the structure of instances and aggregate of a digital twin. The value of the study lies in the creation of theoretical and methodological prerequisites for the digitalization of non-physical objects of logistics management in order to develop rational management decisions using the digital twin containing blocks: consumer value; management system; chain in statics and dynamics; environmental factors.

Keywords: Logistics management; Structure; Supply chain; Digital twin; Management decision; Lost profit

1. Introduction

In the context of global digitalization, in addition to people as main subjects of business management, a new subject emerges: computer. Currently, they seem to play a subsidiary role in management. However, this may be a temporary phenomenon. This aspect of business development is clearly seen in concepts of managing systems and processes that are oriented towards digitalization. So, for example, if Industry 4.0 concept "marries physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better-connected ecosystem for companies that focus on manufacturing and supply chain management"[23], that Industry 5.0 concept "is changing paradigm and brings the resolution since it will decrease emphasis on the technology and assume that the potential for progress is based on collaboration among the humans and machines" [1].

ARTICLE INFO
Received: 16 July 2024 | Accepted: 7 August 2024 | Available online: 20 September 2024

CITATION
Tyapukhin A. Structure of logistics management from a computer perspective. *Supply Chain Research* 2024; 2(1): 6560. doi: 10.59429/scr.v2i1.6560

As a person is biological system and a computer is technical one, they process information in different ways when making managerial decisions. The quantity and quality of information intended for humans and computers differ significantly. Therefore, theory and methodology used by managers when making decisions does not fully correspond to abilities of computers, so it needs to be adapted. At the same time, simply converting paper documents into digital format is not enough. Instead, we need to measure quantitative parameters and describe qualitative characteristics of management objects. We also need to formalize and structure these objects, as well as standardize them by establishing logical relationships between them according to goals and objectives of the study. In addition, it is important to develop standards and algorithms that can be used in virtual environment. It is particularly challenging to process and digitize non-physical management objects, such as human values[50], management systems[58], organizational culture[11], interpersonal relationships[63], subjective factors of internal and external environment[27] and management decisions[31].

Due to the increased focus on the human element in Industry 5.0, the nature and content of a process known as “unphysicalization” is changing. This can involve either the replacement or reduction of physical flows[42], or the sharing of information, negotiation of costs, and listing of goods in virtual environment[46,56]. In this article, “unphysicalization” refers to processes of identifying, formalizing, structuring, and digitizing non-physical management objects related to human activity, as well as integrating them with physical management objects in order to create new software products. These processes include the creation of prototypes, instances, and aggregates of digital twins[24] for logistics management (LM).

The process of “unphysicalization” requires a significant rework of the LM structure[12], in aspects such as: (a) delineating competencies of subjects (who manage?) and management objects (what or who is being managed?), (b) structuring the LM, taking into account its relationships with comparable business processes of supply chain management (SCM), (c) clarifying contents of logistics processes and operations carried out in internal and external environments of the supply chain link, (d) developing a typical organizational structure for the LM division, and (e) creating prerequisites for digitization, primarily of non-physical objects within the LM based on a systematic approach.

The hypothesis of the study is that it is possible to create so-called identification series or digitized set of qualitative features and dichotomies of LM objects and processes. This would allow the development of algorithms and software products based on artificial intelligence, which could help make effective management decisions with minimal loss.

A feature of the study is the development of logically sound LM structure organically integrated into the structure of supply chain link, including the focal enterprise[49], which allows form and reform of organizational structures of SCM[29,60] using instances and aggregate of digital twin created on the basis of their prototype and, accordingly, technical specification developed by customer (user) interested in making informed management decisions[54].

The article structure is as follows. On the basis of terminological analysis, descriptive and faceted methods, functions and structure of LM of local enterprise are substantiated. Further, these functions and structure are refined and supplemented for the focal enterprise that directly interacts with suppliers and consumers. Results obtained in this case make it possible to develop the organizational structure for managing focal supply chain enterprise based on the theory and methodology of digitized LM. This type of management includes hierarchically ordered objects, functions and processes adapted to capabilities of information technologies used in the digital twin of SCM.

2. Literature review

In order for the computer to understand what LM is, it is necessary to investigate the content of its terms and prospects for their use in creating LM digital twin. This requires an assessment of real situation, limitations in the physical world, and the possibility of measuring simulated data[66]. However, there is no clear agreement in the literature on the LM term[41], which makes this topic relevant for study. The computer, not recognizing the LM as clearly defined management object, is unable to identify specific management situation and therefore cannot be helpful when this situation is described by qualitative characteristics. It is sufficient, for example, to recall well-known Harris-Wilson formula[18]. This formula enables us to determine the optimal size of a resource inventory for any enterprise. The result derived from this formula is mathematically validated. However, this does not imply that this result will always hold true in practice. Deviations between the theoretical (calculated) version and its practical implementation are determined by a variety of interconnected factors due to the nature of non-physical management objects related to human activity, which are part of the organizational structure. These deviations can cause lost profits in the supply chain[20].

That is why it is extremely difficult to form the content of Industry 5.0 concept[39,48,64]. Moreover, so far "the Supply Chain 4.0 methodology is still in its infancy in academia and is now being studied more thoroughly by practitioners than academics"[2]. Therefore, there is an obvious priority of empirical SCM research and some misunderstanding by specialists, primarily scientists, of the content of a theory of SCM development based on Industry 5.0 concept, which includes not only supply chains, but also SCM.

A serious problem in creating the LM structure adapted to computer capabilities is the pronounced imperfection of business management terminology. For example, terms "logistics" and "logistics management" are unreasonably duplicated in the literature[17,34,37,38], which, for some reason, are part of SCM[16].

Apparently, there is no need to re-visit the issue of clarifying the relationship between these terms, as it has been accepted as a given by most researchers. The computer can easily display, for example, steps involved in assembling a bolted joint (bolt, washer, nut), but it seems unable to assemble SCM (which may include logistics and LM, or both, in different combinations). One possible solution to this problem was proposed by Tyapukhin (2024)[59], and it still deserves further discussion.

The most well-known and, if not the only, widely used term of LM is the following: "Logistics management is that part of supply chain management that plans, implements, and controls the efficient, 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 …"[17]. An analysis of the content of this term, in relation to the article topic, leads to following conclusions:

Firstly, the human element is implicitly present, including individuals who make and implement management decisions. This is a crucial aspect of Industry 5.0 concept, as it can be challenging to formalize and organize complex system like SCM;

Secondly, there are no prerequisites for formalizing or structuring an object like LM, which would help clarify its role and relations with other parts of management. By the way, when justifying business processes for SCM, LM is often ignored[16,36,61];

Thirdly, if the focus of LM is on flows, then terms of SCM, which are focused exclusively on flow management, are not logically justifiable[13,44,57]. However, if authors still insist that the focus of SCM is on resource flows, they need to make a distinction between terms "supply chain"[17] and "flow";

Fourthly, "plans, implements, and controls" functions have an impact on LM objects, and at the same time coordinate and optimize all logistics activities, as well as integrated logistics activities with other functions, including marketing, sales, manufacturing, finance, and information technology", the structure of which is diverse and therefore, it is insufficiently digitized, including in SCOR[55] and DCOR[5] models, They do not allow making managerial decisions with minimal lost profits and using processes to systematically influence to enterprises, relationships and resource flows.

Currently, efforts are being made to expand upon above basic definition of LM, considering possibilities offered by modern information technologies[23].

An important aspect of the problem under study is the justification of the transparent LM structure, including logistics[20], perceived and modeled by the computer, which, as is known, includes elements and relations between them[1] and is human-oriented, with a strong emphasis on environmental sustainability and supply chain sustainability[25,53].

Many variants of this type of structure have been proposed, but in relation to traditional (non-digital) business management[3,10,14,26,32,35,43,47,52,63]. In these variants, functions and processes performed by subjects and objects of the SCM are differentiated.

However, at the same time, firstly, the quantity and quality of enterprise management functions performed by subjects[15] and resource flows[17] do not coincide, although there is a close correlation between them. Secondly, despite the fairly close alignment of authors' perspectives on LM processes, there is a lack of clear logical connections between these processes and other types of processes, such as procurement, manufacturing, and sales; thirdly, authors did not give enough attention to processes that eliminate cross-functional barriers in supply chains[28]; and, fourthly LM structures created so far do not allow an organic transition into organizational structures for SCM or vice versa[30], even with the help of LM digital twin or instances of the SCM of digital twin aggregate, benefits of using which are justified by specialists[9].

Thus, the literature review has allowed us to formulate following research questions in order to effectively utilize computer capabilities:

RQ 1: What does the typical structure of LM of the supply chain link look like?

RQ 2: What should be the place of LM of focal enterprise in the three-link supply chain?

RQ 3: What are features of the LM structure implemented at the junction of supply chain links?

RQ 4: How is the typical organizational management structure of the LM division of supply chain link formed?

RQ 5: How can LM objects be manually digitized at the stage of creating the digital twin prototype for their accurate transfer into the structure of the overall LM digital twin?

3. Methodology

The required quality of management decisions in supply chains can be achieved if the computer operates with precisely measured and unambiguously described management objects that ensure their copying, modeling and transformation in accordance with precisely measured and unambiguously described factors of internal and external environment. In addition, it requires the development and implementation of

[1]Structure. Cambridge Dictionary. - Available at: https://dictionary.cambridge.org/dictionary/english/structure(accessed 08 February 2024).

adequate methods and algorithms that provide for variety of management decisions, therefore, the methodology of qualitative research is a priority to accomplish the objectives set.

Main stages of this type of study are: firstly, the determination of actual classification attributes of LM objects and their dichotomies based on a descriptive method. Dichotomies refer to two measurement results: (a) quantitative parameters, such as "more" or "less"; (b) states of the object of study, for example, such as project or sample; and (c) stages of the process, such as, for example, preparation and fulfillment; secondly, process of determining variants of management objects using a facet method, which involves logical combinations of classification attributes, makes it possible to use binary matrices and corresponding cells, such as binary codes with symbols "0" and "1"; thirdly, options for converting one management object into another based on synthesis and analysis; fourthly, the formation of structure options based on induction and deduction; and fifthly, choosing the specific structure of the object under study based on optimization methods for the specific supply chain or link.

4. Results

In this section, following are consistently justified and developed: (a) the LM structure of the supply chain link, (b) the LM structure of focal enterprise of three-link supply chain, as well as (c) organizational structure of the LM of supply chain link division.

4.1. Structure of LM in supply chain link

A key role in creating the LM structure is played by a set of classifications, primarily qualitative attributes and their dichotomies. The change in these attributes allows the computer to switch between different management objects, thereby implementing principles of systematic approach. For example, based on qualitative attribute such as "changes in geometric dimensions, mass, configuration, and composition of resources" and dichotomies: "change" and "do not change", it is possible to distinguish between two types of supply chain activities: manufacturing activity (symbol "0") and commercial activities (symbol "1"), which form the basis for binary codes of their components.

Each type of activity, in turn, can be structured into components using following qualitative attributes and dichotomies:

(a) for manufacturing activity: "a supply chain activity planning horizon": current, symbol "0", and strategic (symbol "1"), as well as "a type of supply chain link processes": main (symbol "0"), and auxiliary (symbol "1") (**Figure 1**);

Type of supply chain link processes	**Supply chain activity planning horizon**: Current (0)	Strategic (1)
Main (0)	Technology management (000) (integration and disintegration)	Manufacturing preparation (001)
Auxiliary (1)	*Movement of resources (010)*	*Concentration / distribution (011)*
	LM in manufacturing (010.001)	

Figure 1. Types of manufacturing (symbol "0") activity of supply chain link.

(b) for commercial activity: "a supply chain activity planning horizon": current (symbol "0"), and strategic (symbol "1"), as well as "a type of supply chain link": consumer or supplier (symbol "0"), and intermediary (symbol "1") (**Figure 2**).

	Supply chain activity planning horizon	
	Current (0)	Strategic (1)
Consumer or supplier (0)	Trade (100) (purchases and sales)	Marketing management (101)
Type of supply chain link Intermediary (1)	*Movement of resources (110)*	*Concentration / distribution (111)*
	LMin commerce (110.111)	

Figure 2. Types of commercial (symbol "1") activity of supply chain link.

The joint use of these attributes and dichotomies allows us to identify components (business processes): (a) manufacturing activity: technology management (code "000"), manufacturing preparation (code "001"), movement of resources (code "010"), and concentration / distribution (code "011"); and (b) commercial activity: trade (code "100"), marketing management (code "101"), movement of resources (code "110"), and concentration / distribution (code "111").

The analysis of **Figures 1** and **2** leads us to following conclusions:

(1) classification attributes and dichotomies allow us to create logically related definitions for basic terms, such as:

(a) movement of resources is a type of commercial and/or manufacturing activity within a supply chain aimed at the current transfer of resources (including finished products) to required destinations by agreement between supply chain links and other objects in external environment through the use of intermediaries (logistics providers);

(b) concentration is a type of commercial and/or manufacturing activity within a supply chain that aims to design, form, and optimize flows, processes, and focus systems (enterprises and their relationships);

(c) distribution is a type of commercial and/or manufacturing activity within a supply chain, aims to design, form, and optimize flows, processes, and dissipative systems (enterprises and their relationships).

(2) components "movement of resources", "concentration" and "distribution" create the basis for the formation of two types of LM: in manufacturing (code "010.001") and commerce (code "110.111") and their terms, the content of which is determined by the content of the LM objects. Based on two types of LM, specialists can easily create a universal definition of LM as basic business process in SCM;

(3) **Figures 1** and **2** are convenient because management decisions made, for example, by the marketing management division (code "101"), are based on dichotomous choices: (a) "a consumer or supplier" extends to trade functions (sales and/or purchases) (code "100"), and (b) "a strategic activity planning horizon" for the concentration/distribution function (code "111"). In turn, these functions, through appropriate dichotomies, affect the movement of resources and form chains of management decisions that aim to minimize lost profits. This is achieved by eliminating cross-functional and interoperational barriers that hinder activities of each link in the supply chain. In addition, the decision made by the marketing management department based on the dichotomy of "a supply chain activity planning horizon" concerns functions of manufacturing preparation (code "001") (**Figure 1**), etc.;

(4) to facilitate the structuring and control of management decisions made by the supply chain links, contents of **Figures 1** and **2** can be combined. As follows from contents of **Figure 3**, if, on the qualitative attribute "a complication or simplification of the resource structure", technology management code ("000"), is divided into integration (code "000.0"), and disintegration (code "000.1"), then together with LM in

manufacturing, code ("010.001"), they form such types of manufacturing activities such as connection (code "000.0.010.001"), and disconnection (code "000.1.010.001").

Similarly, using such qualitative attribute as "a transfer or receipt of ownership of a resource", trade can be divided into sales (code "100.1"), and purchases (code "100.0"). Together with the LM in commerce (code "110.111"), they form such types of commercial activities in the supply chain link as procurement (code "100.0.010.001"), and realization (code "100.1.010.001"). If in first case there are some problems with the justification of positions of two deputy directors of manufacturing, then in second case, positions of commercial deputy directorsshould include procurement and realization directors. It is also worth noting that, depending on the type of market, there are two main concepts of manufacturing and commercial activity: traditional and innovative SCM concepts. In first case, the organizational structure of link management does not include a manufacturing preparation division (code "001") (manufacturing focused on technology management) and a marketing management division, code "101" (sales-oriented commerce). In second case, when implementing the client-centric approach[33], it is not possible to do without these divisions. Furthermore, each concept and each type of business process can be assigned specific binary codes. This allows the developer of the digital twin prototype for the LM to take systematic approach to development, improving the quality of instances and the overall quality of the digital twin.

Thus, the content of **Figure 3**, on one hand, provides the basis for designing organizational structure for SCM that includes main divisions that create value for end consumers of products and services[4]. On other hand, it allows for the structuring of management decisions, the delegation of authority, and the allocation of resources according to positions and levels within the organizational structure, as well as the monitoring of their implementation.

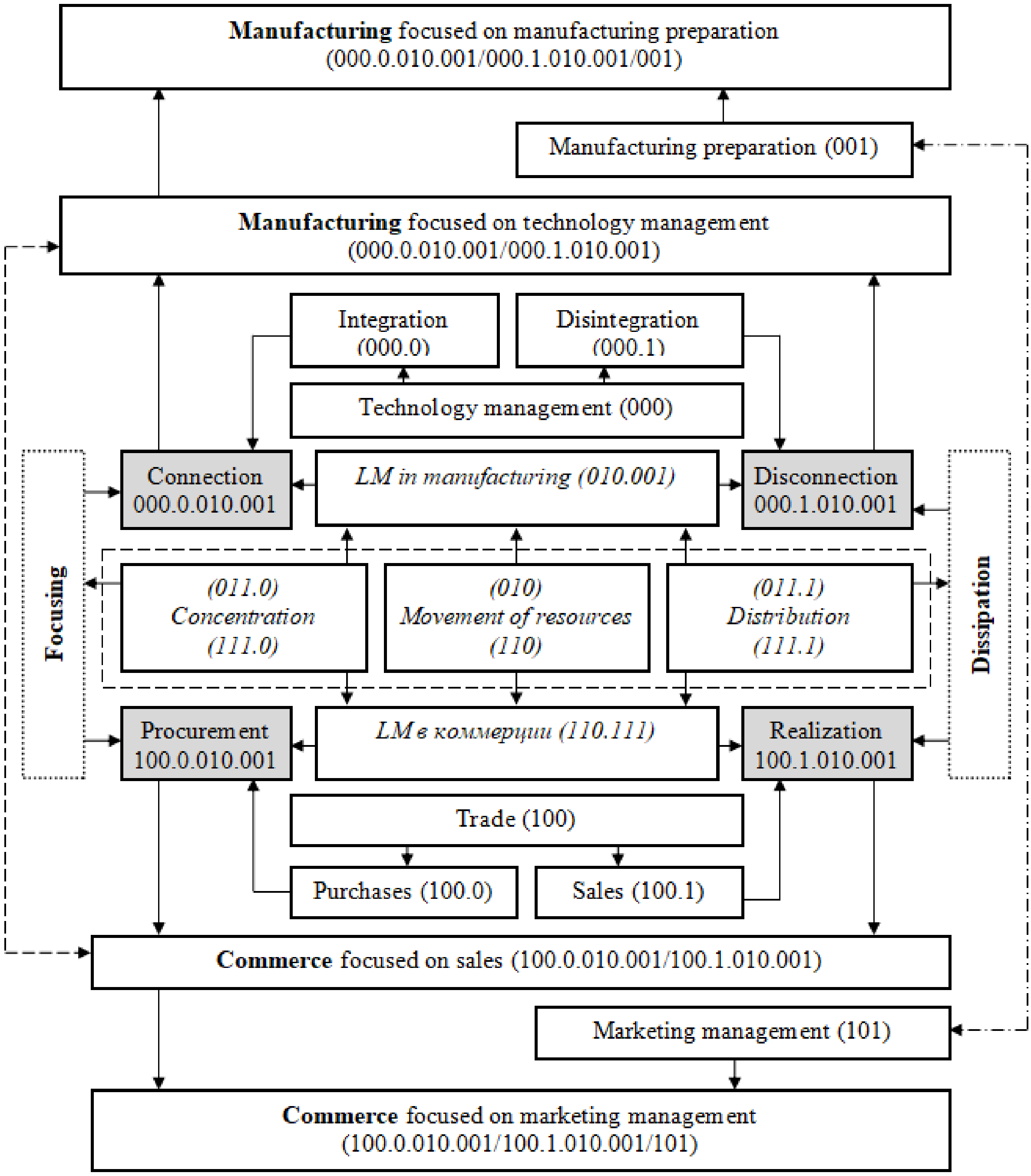


Figure 3. Main activities of supply chain link.

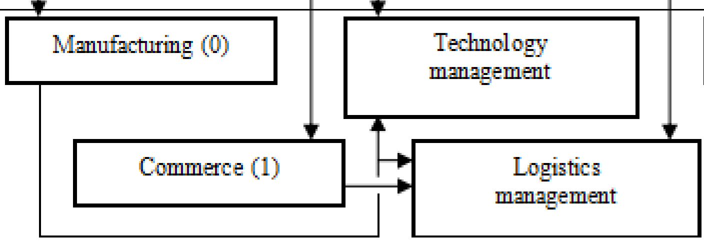
4.2. LM of focal enterprise in three-tier supply chain

In previous section, the supply chain link was considered as separate enterprise that locally implements certain management concept, performs specific types of activities, as well as business processes and includes divisions that form its organizational structure. At same time, this link can act as focal enterprise. In this case it needs to perform additional integrated activities that make adjustments to its organizational structure. To justify these integrated activities, it is recommended to use following previously used qualitative attributes and dichotomies: “a transfer / acquisition of ownership of resources”: no (symbol “0”), and yes (symbol “1”); “changes in geometric dimensions, mass, configuration and composition of resources”: do not change (symbol “0”), and change (symbol “1”); as well as “options for processing batches of resources”: focusing (symbol “0”), and dissipation (symbol “1”).

The joint use of these attributes and dichotomies allows us to justify 8 basic integrated activities of focal enterprise, such as sourcing (code “000”), supply (code “001”), connection (code “010”), disconnection (code “011”), procurement (code “100”), (realization code “101”), consolidation (code “110”), and unbundling (code “111”) (**Table 1**).

Table 1. Classification of integrated activities of focal enterprise.

Transfer / acquisition of ownership of resources: no (0); yes (1)	**Changes in geometric dimensions, mass, configuration and composition of resources:** do not change (0); change (1)	**Options for processing batches of resources:** focusing (0); dissipation (1)	**Integrated activities of focal enterprise**
0	0	0	Sourcing
0	0	1	Supply
0	1	0	Connection
0	1	1	Disconnection
1	0	0	Procurement
1	0	1	Realization
1	1	0	Consolidation
1	1	1	Unbundling



As shown in **Table 1**, in addition to types of activities that were previously discussed (**Figure 3**), we need to add activities such as sourcing and supply based on LM, as well as consolidation and unbundling based on technological management. The second option is significant because, in the presence of commonly produced and marketed resources, they can be customized according to preferences of end consumers of products and services. This means that they can be changed in terms of their geometric dimensions, weight, configuration, and composition. It also means that procurement can be transformed into consolidation and realization can be transformed into unbundling, and vice versa. Additionally, we note that activities shown in **Figure 3** and **Table 1** are coded differently. Therefore, when creating the digital twin prototype for the LM, it is essential to address this issue by developing specialized software solution to resolve this problem.

In order to justify the position of the LM of focal enterprise in three-link supply chain, it is necessary to clarify all of its core business processes again (previously, **Figures 1-3**). To address this issue, it is suggested to use following two sets of qualitative attributes and dichotomies:

(a) “aprocurement activity section”: acquisition (symbol “0”), and delivery (symbol “1”), as well as “procurement activity stage”: preparation (symbol “0”), and fulfillment (symbol “1”);

(b) “arealization activity section”: deliverance (symbol “0”), and dispatch (symbol “1”), as well as “realization activity stage”: preparation (symbol “0”), and fulfillment (symbol “1”).

The joint use of attributes and dichotomies from each group allows us to justify following basic business processes.

(a) procurement activities: purchases (code “100.00”), reception (code “100.01”), movement of resources (code “110”), and concentration (code “111.0”);

(b) realization activities: sales (code “100.10”), transfer (code “100.11”), movement of resources (code “110”), and distribution (code “111.1”) (**Figure 4**).

These basic business processes make it possible to form following integrated activities: marketing management of suppliers (code “101.0”), and marketing management of consumers (code “101.1”); trade from the buyer’s point of view (code “100.00”), and trade from the seller’s point of view (code “100.10”); LM in procurement (code “110.111.0”), manufacturing (code “010.001”), and realization (code “110.111.1”); sourcing (code “100.01.110.111.0”), and supply (code “100.11.110.111.1”); procurement (code “100.00.100.01.110.111.0”), and realization (code “100.10.100.11110.111.1”); consolidation (code “0.100.00.100.01.110.111.0”), and unbundling (code “1.100.10.100.11110.111.1”); and finally commerce (code either “0.100.00.100.01.110.111.0.1.100.10.100.11110.111.1” or “1” by choice).

These business processes and integrated commercial activities make it possible to clarify the organizational structure of focal enterprise and avoid logical errors in supply chains. For example, formally, SCM is based on the concept of “pushing out” products and services[51], in which main enterprise is the supplier of next link in the chain (the consumer). Since modern management is based on the concept of “pulling out” products and services, the logic of the study suggests abandoning the term SCM and replacing it with the term “sourcing chain management” or SoCM, in which the focus of the enterprise is on the consumer who determines the behavior of suppliers.

4.3. Structure of LM implemented at the junction of supply chain links

An important aspect of the study, which involves activities of logistics provider, is to understand basic business processes that take place at the interface between two adjacent links within supply chain. One of these links is focal enterprise.

The study of this aspect involves a transition from the term “chain” to the term “front”[58]and further study of business processes of the sourcing front “$\Sigma h_j \rightarrow i$” (**Figure 5**) and the supply front “$i \rightarrow \Sigma k_j$” (**Figure 6**) of focal enterprise “i”.

Figure 5 shows the sourcing front of focal enterprise “i”, assuming that this enterprise acquires the necessary resources from three suppliers “h” (in this case, business process “purchases” is not taken into account, since it does not relate to LM, but to trade). After the transfer of ownership of resources and before performing the business process “technology management”, code “000”, the enterprise “i” with the help of the business process “concentration” designs, forms and further optimizes the quantity and quality of such management objects as enterprises, relationships, processes and flows, the result of which is a specific plan for effective interaction of the sourcing front of links “$\Sigma h_j \rightarrow i$”.

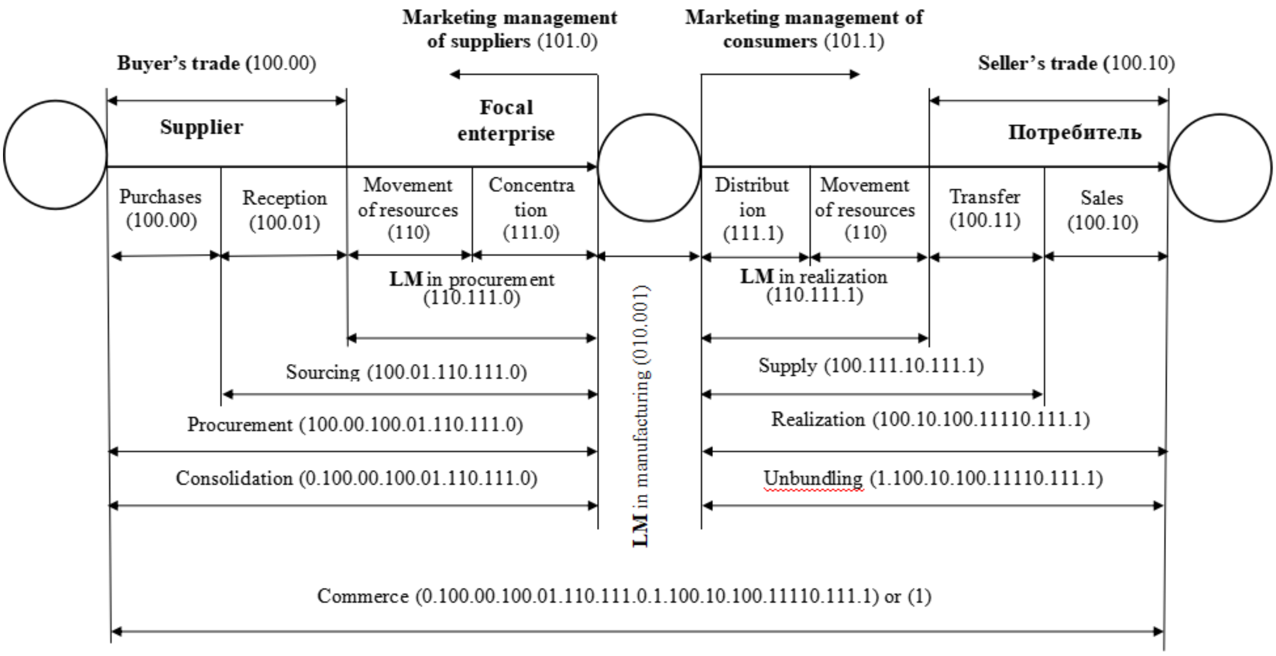


Figure 4. Basic business processes and integrated commercial activities of focal enterprise.

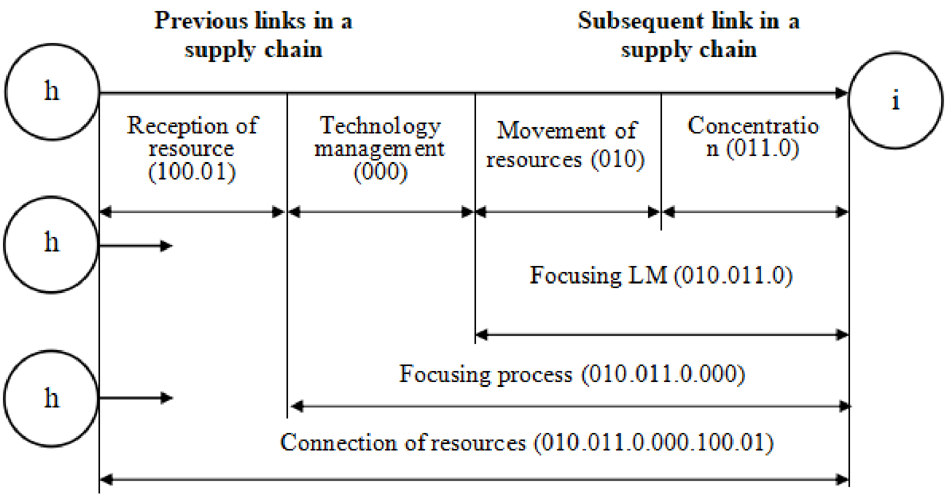


Figure 5. Main types of focusing (connecting) resources.

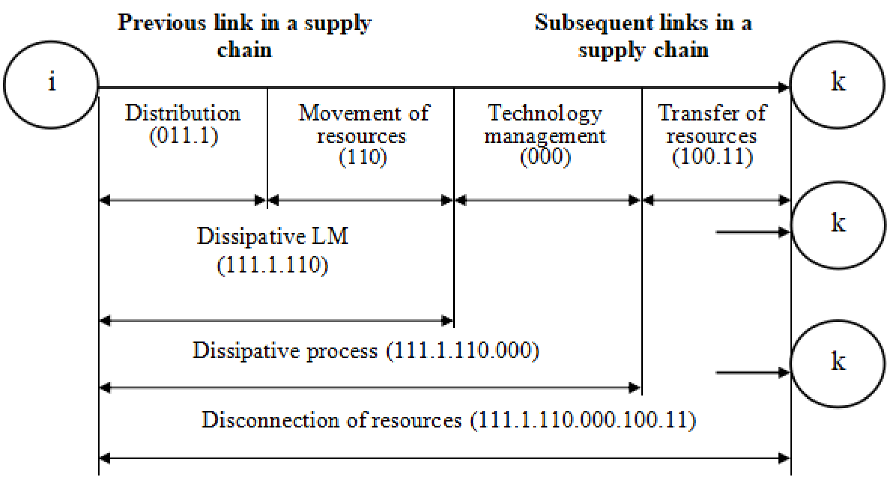


Figure 6. Main types of resources dissipation (disconnection).

This plan provides for the implementation of business processes “reception”, code “100.01”, and “movement of resources”, code “010”. Business processes listed above allow following hierarchically ordered, integrated activities to be formed: focusing LM, code “010.011.0”, focusing process, code “010.011.0.000” and “connection of resources”, code “010.011.0.000.100.01”. Similarly, business processes performed by the supply front “i → Σkj” can be distinguished (**Figure 6**).

The information presented in **Figures 5** and **6** creates prerequisites for clarifying the structure of LM, as well as organizational structure of SCM. It ensures a rational distribution of positions by observing norms of management, delegating authority, and structuring and implementing management decisions.

4.4. Organizational structure of LM of supply chain link

The use of computers in management activities involves not only the creation of virtual copies and models of management objects, but also the development, structuring, formalization, and implementation of managerial decisions at positions and levels within the organizational structure of the enterprise or supply chain. To address this challenge, it is essential to develop the hierarchical LM structure (**Figure 7**).

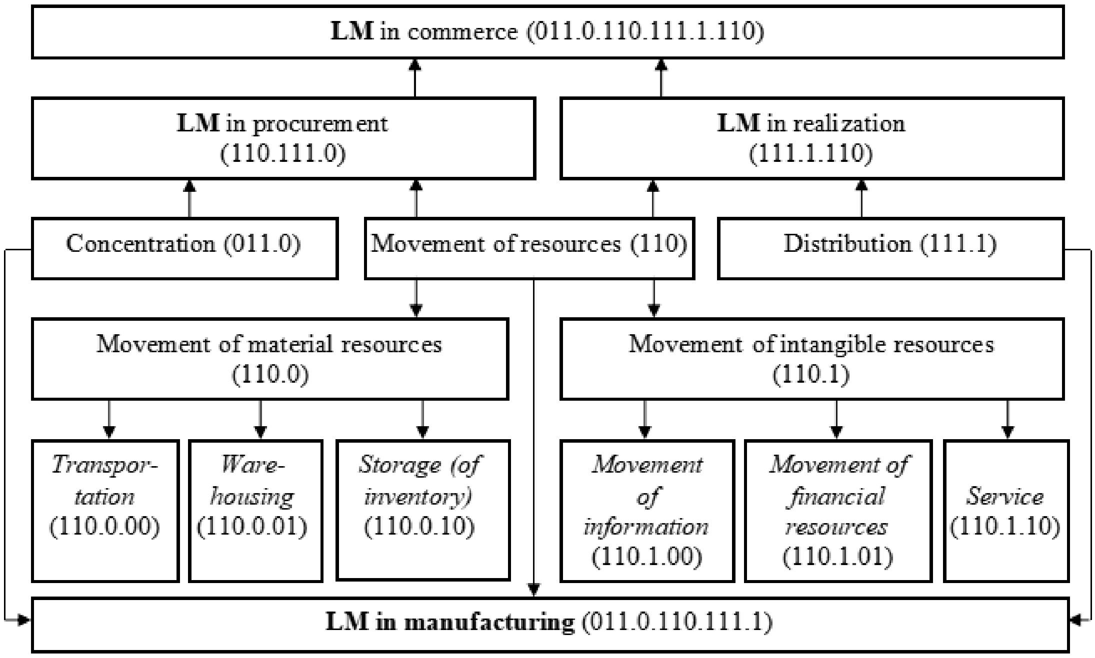


Figure 7. LM structure.

Figure 7 shows four levels of LM development. First level is based on the business process called “movement of material resources” (code “110.0”), which includes transportation (code “110.0.00”), warehousing (code “110.0.01”) and storage (code “110.0.10”). Recall that warehousing ensures the transition of transportation to storage and vice versa. The movement of material resources, code “110.0”, and the movement of intangible resources, code “110.1”, which includes the movement of information, code “110.1.00”, financial resources, code “110.1.01”, and services, code “110.1.10”, form second level of the LM. As follows from contents of **Figure 7**, LM in manufacturing (code “011.0.110.111.1”) includes the concentration (code “110.111.0”), distribution (code “111.1”), and movement of resources (code “110”) within supply chain. And finally, fourth level of development includes LM in commerce, implemented in external environment of this link with the code “011.0.110.111.1.110”, which includes LM for procurement with code “110.111.0”, and LM for realization with code “111.1.110”. One or another level of LM can be used in the link or supply chain, depending on external and internal factors. The identification of these factors is the objective of future study.

Unfortunately, the information in **Figure 7** does not provide a complete picture of the LM structure, therefore it is necessary to clarify the content of such types of its activities as concentration / distribution (codes "111.0.111.1" or "011.0.011.1"), as well as "movement of resources" (codes "110" or "010") (**Figure 8**).

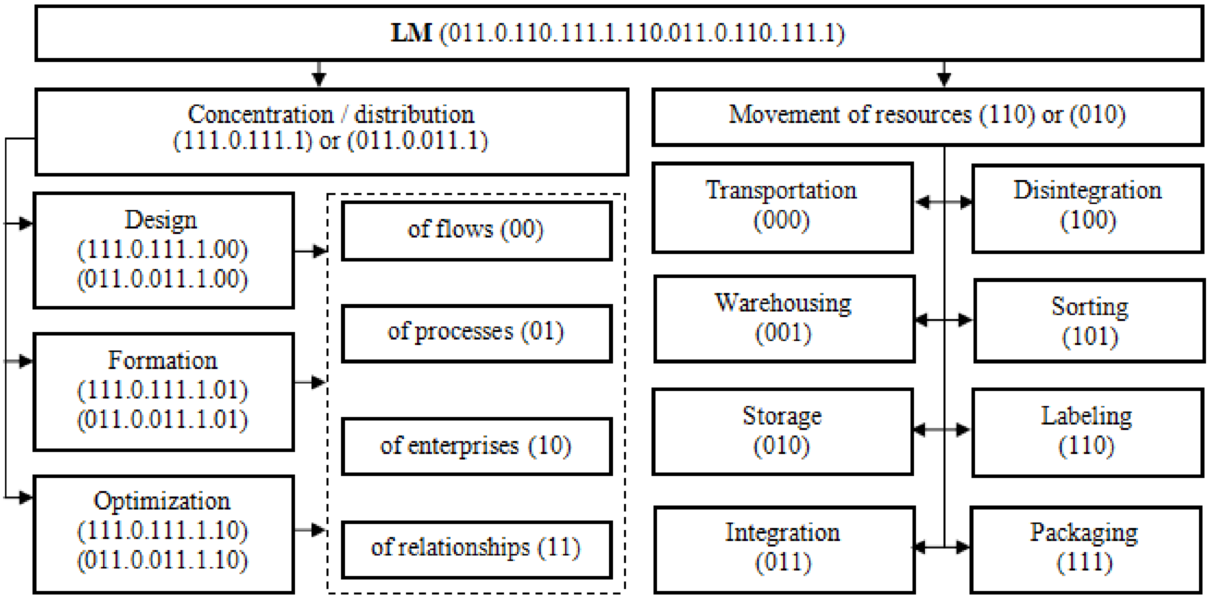


Figure 8. Structure, functions, and operations of LM.

As shown, concentration / distribution provides for design (codes "111.0.111.1.00" or "011.0.011.1.00"), formation (codes "111.0.111.1.01" or "011.0.011.1.01"), and optimization (codes "111.0.111.1.10" or "011.0.011.1.10") of flows (code "00"), processes (code "01"), enterprises (code "10"), and relationships (code "11"). Accordingly, logistics operations of movement of resources should include transportation (code "000"), warehousing (code "001"), storage (code "010"), integration (code "011"), disintegration (code "100"), sorting (code "101"), labeling (code "110"), and packaging (code "111").

Before designing the organizational structure of LM division of supply chain link, it is necessary to show its place and relations with other divisions within the link. A solution to this problem can be found in **Figure 9**.

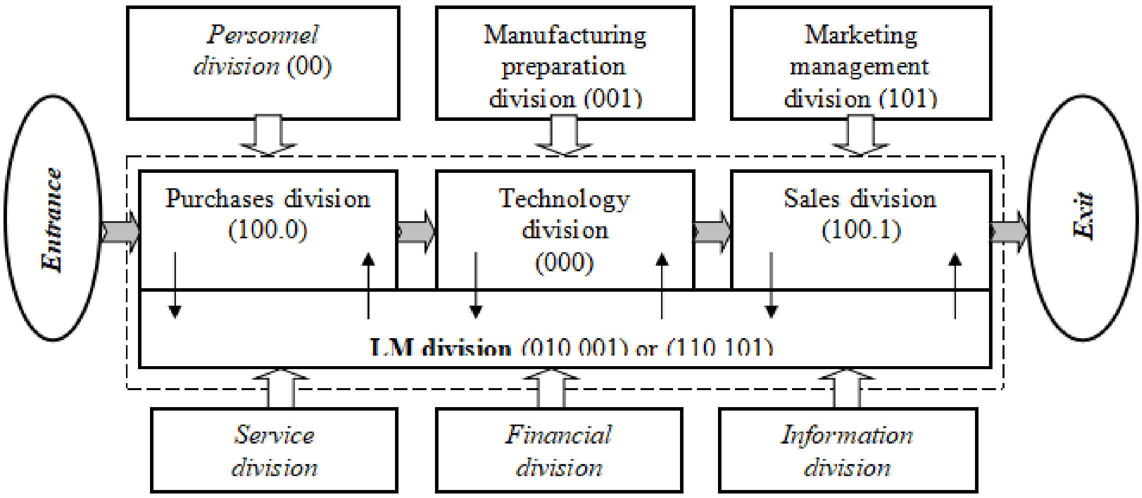


Figure 9. Place of the LM division within the organizational structure of the supply chain link.

Features of this Figure include the separation:

(a) of main divisions of the supply chain link, such as purchases division (code "100.0"), technology management division (code "000"), and sales division (code "100.1") (**Figures 1 and 2**), functioning on the basis of a process approach;

(b) of related divisions of the supply chain, such as service division, financial and information divisions that manage their respective resource flows;

(c) of support divisions such as manufacturing preparation division, code "001" (**Figure 1**), marketing management division, code "101" (**Figure 2**) and personnel division, code "00".

It follows from contents of **Figure 9** that the main objective of the LM division is to eliminate cross-functional barriers to managing business processes in supply chains and inter-operational barriers within each business process, thereby ensuring the smooth flow of resource flows.

Thus, basic prerequisites for the development of organizational structure of LM division of supply chain link are formulated (**Figure 10**).

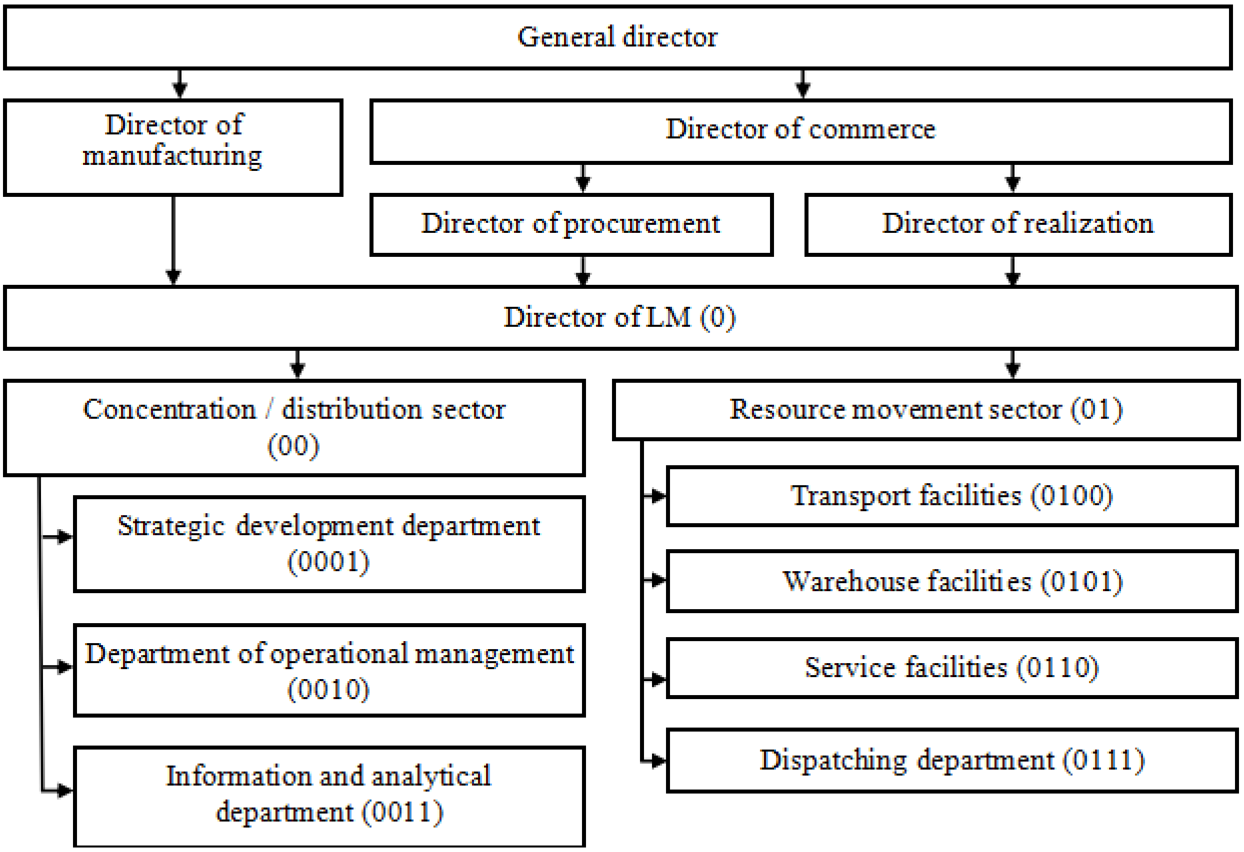


Figure 10. Typical organizational structure of LM division of supply chain link.

Figure 10 shows that the director of the LM, symbol "0", reports, at a minimum, to three other directors: procurement, manufacturing, and realization. Therefore, the structure of LM division exhibits signs of matrix organizational structure. In turn, director of LM influences concentration / distribution sectors (code "00") and resource movement (code "01"). The concentration/distribution sector (code "00"), includes strategic development department (code "0001"), department of operational management (code "0010"), and also information and analytical department (code "0011"). At same time, the strategic development department is engaged in the design (selection) of enterprises, relationships, processes and flows. The department of operational management is responsible for the formation and optimization of various processes, while the information and analytical department provides necessary information, methodological tools, and recommendations to specialists in areas of concentration and distribution. The resource movement sector (code “01”), consists of transport (code “0100”), warehouse (code “0101”), and services (code “0110”) facilities, as well as dispatching department (code “0111”).

Therefore, the study employed the systematic approach to clarify the structure of LM system at various levels, including: (a) supply chain links, (b) three-link chains, (c) intersections between these chains, (d) resource movement, and (e) interactions with other parts of the supply chain. Based on these findings, type organizational structure for the logistics department is proposed.

Obtained results provide theoretical and methodological foundations for digitalizing activities and business processes in supply chains. They also enable the modeling of the organizational structure and structure of the LM division, as well as the structuring and formalizing of management decisions according to positions and levels within this structure.

5. Discussion

The implementation and development of Industry 5.0 requires solving many problems[1,7,21,22]. Additionally, some of these challenges cannot be overcome when implementing Industry 4.0 concept[8]. They need to be addressed within a new framework that combines information technology with human creativity and intuition in order to create a more collaborative and flexible manufacturing process[62]. The main source of these problems is a weak development of theory, methodology, and techniques for identifying, formalizing, structuring, and digitalizing intangible management objects related to human activities. This is because it is extremely challenging to measure and optimize results, due to the lack of suitable scales and tools. In addition, the existing theory and methodology for managing objects in business are based on peculiarities of how humans perceive information, and, in their current form, they are not compatible with computers.

The way out of this situation is to use descriptive and faceted methods of qualitative research on non-physical management objects. This allows us to create standards (virtual objects) that can be modeled and transformed based on their actual classification attributes and dichotomies. Thus, it seems quite feasible to develop digital twin for managing physical and non-physical LM objects, the purpose of which are management decisions that minimize the lost profits of supply chain links compared to competitors. Moreover, with the help of digital twins of this type, it is possible to structure these decisions by positions and levels of organizational management structure, eliminating possible inter-functional and inter-operational barriers in scalar management chains.

This article presents results of adapting traditional theory and methodology of LM to capabilities of the computer operating with a set of interconnected codes of physical and non-physical management objects that form channels for processing large amount of information in accordance with effects of the user of LM digital twin.

Practice shows that the author’s approach to justifying study results often raises many questions and leads to partial misunderstandings about the methodology used. Therefore, in order to solve urgent problems with implementing Industry 5.0 concept in SCM, a number of key aspects of managing non-physical LM objects will need to be discussed, among which are: creating a set of actual classification attributes and dichotomies characterizing LM objects; creating standards (virtual objects) of the LM; development of a methodology for identifying real LM objects and achieving the required level of accuracy; developing capabilities of artificial intelligence and self-learning systems capable of optimizing LM objects[45], using their qualitative attributes and dichotomies for this goal; adapting previously gained experience in the field of LM and creating on this basis an empirical block for making rational management decisions, etc.

6. Conclusion

The study we conducted has yielded results that show signs of scientific significance. These include: typical structure of the LM supply chain link, the place of focal enterprise in the three-link supply chain, features of the LM structure implemented at the junction of supply chain links, typical organizational structure of the LM supply chain division, and the system of binary codes for correctly transferring LM objects into the structure of instances and aggregates of the digital twin.

The contribution to the theory comes from the development not only of the link structure of the LM, but also of three-link supply chain, in which the link acts as focal enterprise that is adapted to computer capabilities and software. This allows for the development of methods and algorithms to support and make managerial decisions aimed at minimizing supply chain profit losses.

The contribution to practice lies in the ability for customers to develop the LM digital twin, followed by technical specification for developing instances and aggregate of this digital twin. In addition, this article raises the issue of creating artificial intelligence systems that operate with qualitative attributes and dichotomous, and are focused on making optimal management decisions based on factors from external and internal environments.

Creators of future LM digital twin implemented in SCM should take into account a number of fundamentally important limitations, which are as follows: very high labor intensity, as well as significant time and resources spent on creating logically linked terms of objects and processes of LM based on a set of relevant classification attributes and dichotomies; lack of methodology for integration and sharing both physical and non-physical objects of LM; the lack of methods and tools for the development of LM algorithms available for the use of artificial intelligence as essential component of digital twin, designed to develop innovative management decisions, etc.

Further study is expected to refine the structure of typical activities and business processes in manufacturing and commerce related to LM. This will create necessary prerequisites for the creation of digital twin prototype for logistics provider servicing links of "N"- link supply chain. It will also explore possibilities of creating the LM structure that takes into account not only economic aspects, as suggested by Xu et al. (2021)[65], but also social and environmental considerations related to Industry 5.0 concept. Furthermore, it will investigate the potential for adapting technologies of Industry 4.0 concept to meet needs and values of individuals in digital society.

Conflict of interest

Authors declare that there is no conflict of interest.

References:

1. Adel A (2022). Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas. Journal of Cloud Computing 2022; 11(40). Available from: https://journalofcloudcomputing.springeropen.com/articles/10.1186/s13677-022-00314-5#citeas. doi: 10.1186/s13677-022-00314-5

2. Al Kurdia B, Alzoubib HM, Alshuridehc MT, Alquqae EK, Hamadneh S. Impact of supply chain 4.0 and supply chain risk on organizational performance: An empirical evidence from the UAE food manufacturing industry. Uncertain Supply Chain Management 2023; 11: 111-118. Available from: https://www.growingscience.com/uscm/Vol11/uscm_2022_130.pdf
3. Al Salaimeh S, Miqdadi A. Structuring of Logistics Management Organizational-Technological System. Mordovia University Bulletin 2018; 28(2): 175-180. doi: 10.15507/0236-2910.028.201802.175-180
4. AMA. American Marketing Association Definition of Marketing. 2017. Available from: https://www.ama.org/AboutAMA/Pages/Definition-of-Marketing.aspx
5. APICS. Association for Operations Management. APICS Dictionary, thirteenth edition, 2010. Available from: http://www.apics.org/apics-for-individuals/publications-and-research/apics-dictionary
6. Ayles C, Panades R. An Investigation of Relationship Difficulties and HelpSeeking. London: One Plus One; 2005.
7. Baig M, Yadegaridehkordi E. Exploring moderating effects of industry 4.0 adoption on sustainable performance of Malaysian manufacturing organizations. Journal of Industrial and Production Engineering2023; 40(4): 271–286. doi: 10.1080/21681015.2023.2190766
8. Bajic B, Rikalovic A, Suzic N, Piuri V. Industry 4.0 Implementation Challengesand Opportunities: A Managerial Perspective. IEEE Systems Journal2021; 15(1): 546–559. doi: 10.1109/jsyst.2020.3023041
9. Binsfeld T, Gerlach B. Quantifying the Benefits of Digital Supply Chain Twins—A Simulation Study in Organic Food Supply Chain. Logistics2022; 6: 46. doi: 10.3390/logistics6030046
10. Bowersox DJ, Closs DJ, Cooper MB. Supply Chain Logistics Management. International edition. USA: The McGraw-Hill Companies Inc.; 2002.
11. Brown A. Organizational Culture. Prentice hall; 1998.
12. Chan HL, Choi TM. Logistics management for the future: the IJLRA framework. International Journal of Logistics Research and Applications 2023; 1-19. doi: 10.1080/13675567.2023.2286352
13. Chen HH, Liu K-S, Chen S-C, Chang C-Y, Hsieh KS, Yang Y-W. An overview of workflow management system structure in the supply chain. Australian Journal of Business and Management Research2012; 2(04): 12-19.
14. Christopher M. Logistics & Supply Chain Management. Fourth edition. Harlow, Edinburgh: Pearson Education Limited; 2011.
15. Cole GA. Management Theory and Practice. 6th ed. London: Book Power; 2004.
16. Cooper MC, Lambert DM, Pagh JD. Supply Chain Management: More than a New Name for Logistics. International Journal of Logistics Management1997; 8(1): 1-14. doi: 10.1108/09574099710805556
17. CSCMP. Council of Supply Chain Management Professionals. CSCMP Supply Chain Management Definitions and Glossary. 2013. Available from: https://cscmp.org/CSCMP/Academia/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921
18. Erlenkotter D. Note – An early classic misplaced: Ford W. Harris's economic order quantity model of 1915. Management. Science 1989; 35(7): 898–900. doi: 10.1287/mnsc.35.7.898
19. Fawcett SE, Magnan GM,McCarter MW . Benefits, barriers, and bridges to effective supply chain management. Supply Chain Management2008; 13(1): 35-48. doi: 10.1108/13598540810850300
20. Fawcett SE, Wallin C, Allred C, Fawcett MA, Magnan GM. Information technology as an enabler of supply chain collaboration: a dynamic-capabilities perspective. Journal of Supply Chain Management2011; 47(1): 38–59. doi: 10.1111/j.1745-493X.2010.03213.x
21. Ghobakhloo M, Iranmanesh M, Tseng M-L, Grybauskas A, Stefanini A, Amran, A. Behind the definition of Industry 5.0: a systematic review of technologies, principles, components, and values. Journal of Industrial and Production Engineering2023; 40(6): 432-447. doi: 10.1080/21681015.2023.2216701

22. Cotta J, Breque M. Industry 5.0 Towards a sustainable, humancentric and resilient European industry. European Commission. 2021. Available from: https://op.europa.eu/en/publication-detail/-/publication/468a892a-5097-11eb-b59f-01aa75ed71a1/
23. Götz M, and Jankowska B. Adoption of Industry 4.0 Technologies and Company Competitiveness: Case Studies from a Post-Transition Economy. Foresight and STI Governance2020; 14(4): 61–78. doi: 10.17323/2500-2597.2020.4.61.78
24. Grieves M, Vickers J. Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems. In: Kahlen F-J, Flumerfelt S, Alves A. (Editors) Transdisciplinary Perspectives on Complex Systems: New Findings and Approaches, Cham: Springer; 2017. 85–113. doi: 10.1007/978-3-319-38756-7_4
25. Grosse EH. Application of Supportive and Substitutive Technologies in Manual Warehouse Order Picking:A Content Analysis. International Journal of Production Research2023: 62(1): 1-21. doi: 10.1080/00207543.2023.2169383
26. Harrison A, van Hoek R. Logistics Management and Strategy Competing through the supply chain. Edinburgh: Pearson Education Ltd.; 2008.
27. Hayes J. The Theory and Practice of Change Management. 4th edn, England: Palgrave Macmillan; 2014.
28. Hendriksen C. Artificial intelligence for Supply Chain Management: Disruptive Innovation or Innovative Disruption? Journal of Supply Chain Management 2023; 59(3): 65-76. doi: 10.1111/jscm.12304
29. Holschbach E, Tank D. Intra-Organizational Structures of Supply Chain Management: A Research Agenda and Preliminary Findings. In: IPSERA Conference, Dortmund, 2016: 25. Available from: https://www.researchgate.net/publication/299468520_Intra-Organizational_Structures_of_Supply_Chain_Management_A_Research_Agenda_and_Preliminary_Findings
30. Hu J. Collaborative filtering based talent development algorithm in sustainable modern logistics management project. Journal of Industrial and Production Engineering 2024; 1-14. doi: 10.1080/21681015.2024.2351502
31. Huber GP. Managerial decision making. Glenview, IL: Scott, Foresman and Co.; 1980.
32. Kanagavalli G, Azeez R. Logistics and E- Logistics Management: Benefits and Challenges. International Journal of Recent Technology and Engineering 2019; 8(4): 12804-12809. doi: 10.35940/ijrte.D7179.118419
33. Kumar V, Reinartz W. Customer Relationship Management Concept, Strategy, and Tools. Third edition. Germany: Springer-Verlag GmbH; 2006. doi: 0.1007/978-3-662-55381-7
34. IILM. Indian Institute of materials management. Logistics and warehousing management. 2020.Available from: https://iimm.org/wp-content/uploads/2019/12/Logistics-and-Warehousing-Management.pdf
35. Islam DMZ, Meier JF, Aditjandra PT, Zunder TH, Pace P. Logistics and supply chain management. Research in Transportation Economics2013; 41: 3-16. doi: 10.1016/j.retrec.2012.10.006
36. Lambert DM, Cooper MC, Pagh JD. Supply Chain Management: Implementation Issues and Research Opportunities. International journal of Logistics Management1998; 9(2): 1–20. doi: 10.1108/09574099810805807
37. Lambert DM Stock JR, Cooper MC. Fundaments of Logistics management. Boston, etc.: Irvin McGraw-Hill; 1998.
38. Langley CJ, Coyle JJ, Gibson BJ, Novack RA, Bardi EJ. Managing supply chain: A logistics approach, 8th ed., South-Western Cengage learning; 2008.
39. Leng J, Sha W, Wang B, Zheng P, Zhuang C, Liu Q, Wuest T, Mourtzis D, Wang L. Industry 5.0: Prospect and retrospect. Journal of Manufacturing Systems2022; 65: 279–295. doi: 10.1016/j.jmsy.2022.09.017
40. Li X. Optimization of logistics flow management through big data analytics for sustainable development and environmental cycles. Soft Computing2024; 28(2): 2701–2717. doi: 10.1007/s00500-023-09591-x
41. Lourenço HR. Logistics management. An Opportunity for Metaheuristics. Chapter 15. In: Rego C., Alidaee, B. (Editors) Metaheuristics Optimization via Memory and Evolution, Kluwer Academic Publishers, 2005: 329-356. doi: 10.1007/0-387-23667-8_15

42. Malhotra A, Gosain S, El Sawy OA. Absorptive capacity configurations in supply chains: gearing for partner-enabled market knowledge creation. MIS Quarterly: Management Information Systems2005; 29(1): 145-187. doi: 10.2307/25148671
43. Mangan J, Lalwani C, Butcher CT. Global logistics and supply chain management. Weley Higher Education; 2008.
44. Mentzer JT, Myers MB, Stank TP. Handbook of Global Supply Chain Management. University of Tennessee-Knoxville: SAGE Publications Inc.; 2007.
45. Min H. Artificial intelligence in supply chain management: Theory and applications. International Journal of Logistics: Research and Applications2010; 13(1): 13–39. doi: 10.1080/13675560902736537
46. Mital M, Del Giudice M, PapaA. Comparing supply chain risks for multiple product categories with cognitive mapping and analytic hierarchy process. Technological Forecasting and Social Change2018; 131: 159-170. doi: 10.1016/j.techfore.2017.05.036
47. Murphy PRJr, Knemeyer AM. Contemporary Logistics. Twelfth edition. Harlow: Pearson Education Ltd.; 2018.
48. Nayeri S, Sazvar Z, Heydari J. Towards a responsive supply chain based on the industry 5.0 dimensions: A novel decision-making method. Expert Systems with Applications2023; 213(C), 119267. doi:10.1016/j.eswa.2022.119267
49. Paulraj A, Chen IJ, Lado AA. An Empirical Taxonomy of Supply Chain Management Practices. Journal of Business Logistics2012; 33(3): 227–244. doi: 10.1111/j.0000-0000.2012.01046.x
50. Porter ME. Competitive Strategy: Techniques for Analyzing Industries and Competitors. New York, NY: The Free Press; 1985.
51. Pyke DF, Cohen MA. Push and pull in manufacturing and distribution systems. Journal of Operations Management 1990; 9(1): 24–43. doi: 10.1016/0272-6963(90)90144-3
52. Rushton A, Croucher P, Baker P. The handbook of logistics and distribution management: understanding the supply chain. Fifth edition. London: Kogan Page Ltd.: 2014.
53. Saldanha-da-Gama F. Facility Location in Logistics and Transportation: An Enduring Relationship. Transportation Research Part E: Logistics and Transportation Review 2022; 166: 102903. doi: 10.1016/j.tre.2022.102903
54. Shapira Z. Organizational Decision-Making. Cambridge: University Press; 2010.
55. Supply Chain Council. Supply Chain Operations Reference Model. Revision 11.0. 2012. Available from: https://docs.huihoo.com/scm/supply-chain-operations-reference-model-r11.0.pdf
56. Scuotto V, Del Giudice M, Pereira V, Malhotra A. Guest editorial: (Un)physicalization (digitalization) of supply chain management. International Journal of Physical Distribution & Logistics Management2023; 53(5/6): 557-562. doi: 10.1108/IJPDLM-06-2023-551
57. Stock J, Boyer S. Developing a consensus definition of supply chain management: A qualitative study. International Journal of Physical Distribution & Logistics Management2009; 39(8): 690–711. doi: 10.1108/09600030910996323
58. Tyapukhin AP. A Systematic Approach to Substantiating Chain Management Structures in Businesses. Chapter 5. In: Nelson WD (Editor), Advances in Business and Management. December. 20, USA: Nova Science Publishers, Inc.; 2022: 167 – 191. doi: 10.52305/NGNY3123
59. Tyapukhin AP. Systematic approach to the designing management objects: from concept to organisational structure. International Journal Management Concepts andPhilosophy2024;17(1)**:** 58–82. doi:10.1504/IJMCP.2023.10054451
60. USAID. Logistics Management Units: What, Why, and How of the Central Coordination of Supply Chain Management. Arlington, Va. 2010. Available from: https://www.ghsupplychain.org/sites/default/files/2019-07/LogisticsMgmtUnits_Guide.pdf
61. van der Vorst JGAJ. Supply Chain Management: theory and practices. Cambridge: Training College Britain; 2004.
62. Wang H, Lv L, Li X, Sun C, Luo G. A safety management approach for Industry 5.0′s human-centered manufacturing based on digital twin. Journal of Manufacturing Systems2023; 66(2): 1-12. doi: 10.1016/j.jmsy.2022.11.013

63. Waters D. Global Logistics and Distribution Planning: Strategies for Management. London: Kogen Page Ltd.; 2003.
64. Yuan X-M, Xue A. Supply Chain 4.0: New Generation of Supply Chain Management.Logistics2023; 7(9): 1-4. doi: 10.3390/ logistics7010009
65. Xu X, Lu Y, Vogel-Heuser B, Wang L. Industry 4.0 and Industry 5.0—Inception, conception and perception. Journal of Manufacturing Systems2021; 61: 530–535. doi: 10.1016/j.jmsy.2021.10.006
66. Zhang R, Wang F, Cai J, Wang Y, Guo H, Zheng J. Digital Twin and Its Applications: A Survey. The International Journal of Advanced Manufacturing Technology2022; 123(11-12): 4123–4136. doi: 10.1007/s00170-022-10445-3