LogForum 2014, 10 (3), 331-349

> Scientific Journal of Logistics <

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

PRODUCTION-LOGISTIC SYSTEM IN THE ASPECT OF STRATEGIES FOR PRODUCTION PLANNING AND CONTROL AND FOR LOGISTIC CUSTOMER SERVICE

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ABSTRACT. Background: The authors made multi-dimensional review of production and logistic strategies in order to prove their coherence in shaping internal and external supply chain. The paper is concluded with definition of production-logistic system as an object of modeling in transformation of business systems of manufacturing companies.
Material and methods: The paper is based on analysis of state of the art presented in the literature on the subject of production and logistics strategies. Publications of key importance were selected to identify genesis and basic assumptions of strategies and their functioning. Comparative synthesis of logistic and production strategies identified is developed with respect to authors' experience in application of predefined tools and methods characteristic for strategies identified.
Results: The result of the work conducted is consolidation of production and logistic strategies according to multi-variant customer service and original definition of production and logistic system.
Conclusions: Production system and logistic system can and should be treated as equal elements in context of material flows management in internal and external supply chains. Such approach enables modeling of both systems as coherent elements realizing selected strategy of customer service.

Key words: MRP, Lean, TOC, Agile, ECR, Quick Response, SCM, production system, logistic system.

INTRODUCTION

The goal of the following paper is to develop a synthetic classification of strategies within areas of production and logistics in order to:

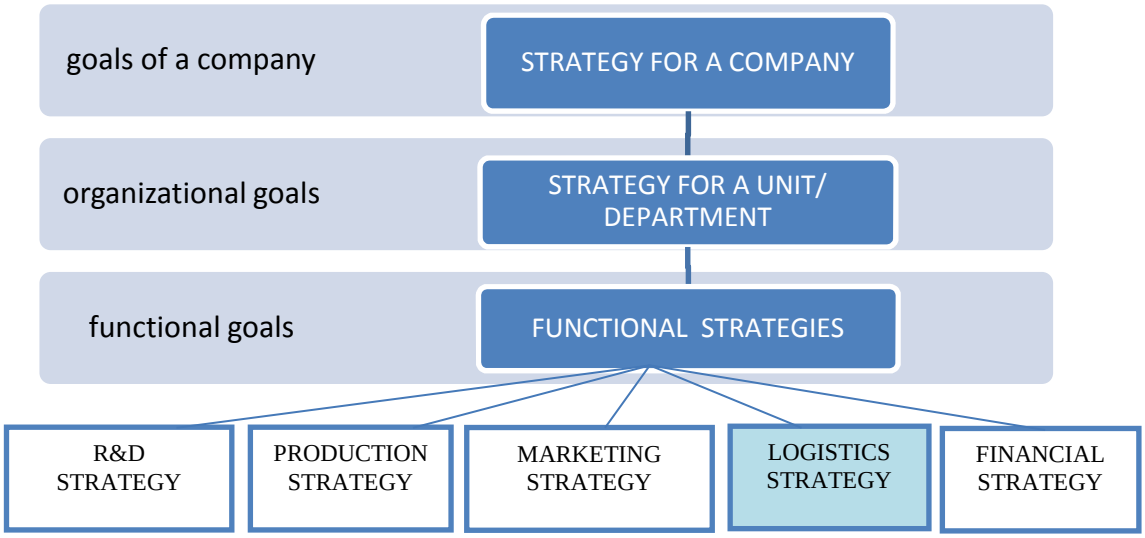
- Introduce chronology to identify the moment in which the predefined solutions appeared or were developed,
- Introduce their range to define the area of application of each solution,
- Identify the level of integral integration of businesses applying the strategies predefined as well as their integration with environment.

This analysis enables the aggregation of production and logistics strategies to demonstrate their consistency in the development of internal and external supply chain. The article concludes with a definition of production and logistics system as an object of modeling in the transformation of business systems manufacturing companies.

Defining a logistics strategy and typology for solution within range of logistics requires mostly identification of place for logistic

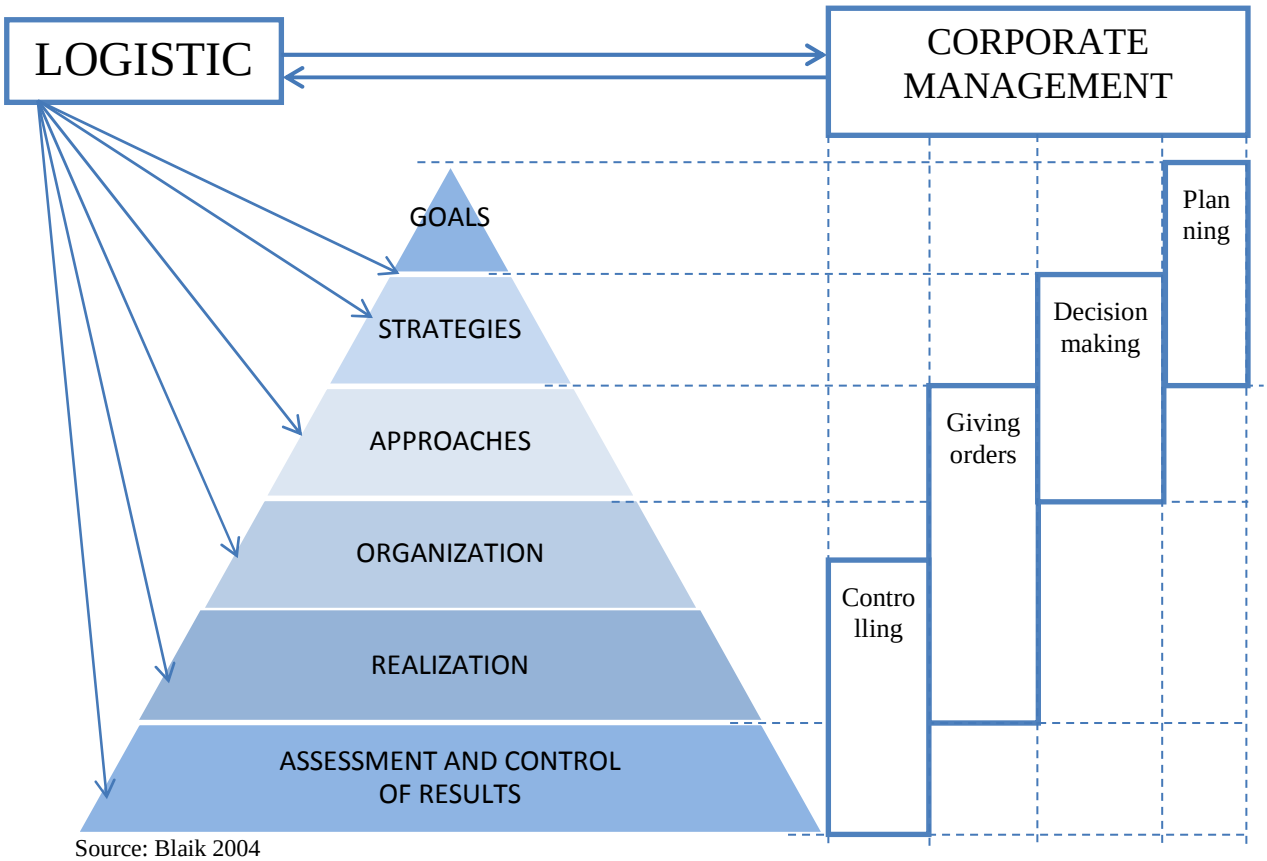
Citation: Hadaś Ł., Stachowiak A., Cyplik P., 2014, Production-logistic system in the aspect of strategies for production planning and control and for logistic customer service. LogForum 10 (3), 331-349
URL: http://www.logforum.net/vol10/issue3/no9
Accepted: 13.05.2014, on-line: 30.06.2014.

strategy in a company [Słowiński 2008]. Undoubtedly, logistics strategy is a functional solution, subordinated to global corporate strategy. The hierarchy for strategies is introduced in the figure below.



Source: Sołtysik 1996

Fig. 1. Place of logistics strategy in hierarchy of corporate strategies
Rys. 1. Miejsce strategii logistycznej w hierarchii strategii przedsiębiorstwa



Source: Blaik 2004

Fig. 2. Influence of logistics on corporate management
Rys. 2. Wpływ logistyki na zarządzanie przedsiębiorstwem

As a functional solution, logistics strategy is to support realization of global and organizational goals through optimal composition of factors crucial for customer service - i.e. quality, time, flexibility and cost [Śliwczyński 2008]. Thanks to typical for logistics integration of operations, from operational to strategic level with f.ex. keeping the deadline in transport realization a company achieves high level of customer service, influence of this functional area and strategy that defines it on global strategy is substantial [Blaik 2004], which is introduced in figure 2.

Hence, logistic strategy is on one hand a consequence of global corporate goals, on the other it influences the goals, as a performance feedback. Generally, such relation does not refer to entire company, but only to its competences and issues within the area of logistics. According to experts strategic decisions within logistics refer mostly to [Witkowski 1995, Kisperska-Moroń 2002]:

- Definition of customer service standards,
- Identification of number of and location of warehouses, distribution centers and making basic decisions concerning their equipment,
- Developing general principles of inventory management for materials and raw materials necessary to manufacture goods and provide services,
- Identification of a range of logistic services in relations with suppliers and customers and definition of a range of third party services,
- Taking some assumptions concerning IT support.

The issues are of internal character as they determine internal processes of a company (including procurements, production and sales) and of external character as well, as they define links with market environment (suppliers, co-operators, customers). The consequence of the assumption above mentioned is the conclusion that logistics strategies should on one hand refer to internal and external links, on the other however, as solutions on a lower level, offer a variety of methods, techniques and tools providing meeting predefined logistics goals.

TYPOLOGY OF LOGISTIC STRATEGIES

Attempts to systematize the functioning logistics strategies on the market and used in enterprises were undertaken repeatedly, beginning with 60-70 of XX century [Gustaffson 2006]. To build a typology of logistics strategies different criteria were used, from the most general, related to the global strategy, to the detailed, related to the organization of the various logistic subsystems.

Currently, the research is being conducted to identify trends and phenomena that affect the shape of logistics, as well as logistics and manufacturing systems strategy. The importance of logistics for companies is what makes such identification crucial, both from the point of view of practitioners, employees of enterprises, in which logistics and production processes are implemented, and scientists and researchers whose interests are related to those areas. Hence the initiatives striving for definition of state of the art both for knowledge and practice within the areas, among which BVL report is focused on trends and logistic strategies in supply chains. Report developed on the basis of 1757 surveys, confronted to 60 interviews with top managers of companies from all over the world, representing various industries [Handfield et al. 2013]. According to the report, the most often mentioned trends include [Handfield et al. 2013]:

- Customers' expectations,
- Networked economy,
- Pressure on costs,
- Globalization,
- Lack of experts,
- Volatility of markets,
- Sustainable development,
- Growing risk,
- Technology development,

with their relative importance varying over time. This variety of factors makes the company grapple not only with classical, related to costs and efficiency issues but also

take into account environmental issues, innovation, risk-sharing and many others, often associated with conflicting objectives. The logistics goals the most frequently mentioned by managers, in turn, include the following [Handfield et al. 2013]:

- Meeting customers' requirements,
- On-time deliveries,
- Green logistics,
- Delivery cycle,
- Innovation,
- CSR,
- Logistics costs,
- Logistics quality,
- Scheduling flexibility.

The way of the goals realization is a logistic strategy of a company. According to the logic developed, on the general level there are the following approaches identified, either basing on cost minimization, either on service differentiation [Penc 1996, Kisperska-Moroń 2002]:

- Substitution strategy, referring to general strategies of cost-leadership,
- Complementarity strategies, referring to strategies of differentiation and concentration.

Similar conclusion and approach is presented in the works of [Bourlakis and Bourlakis 2001], [Fine and Hax 1985], [Towill and Christopher 2002].

Furthermore, the following solutions are identified in the predefined functional areas of the company [Witkowski 1995]:

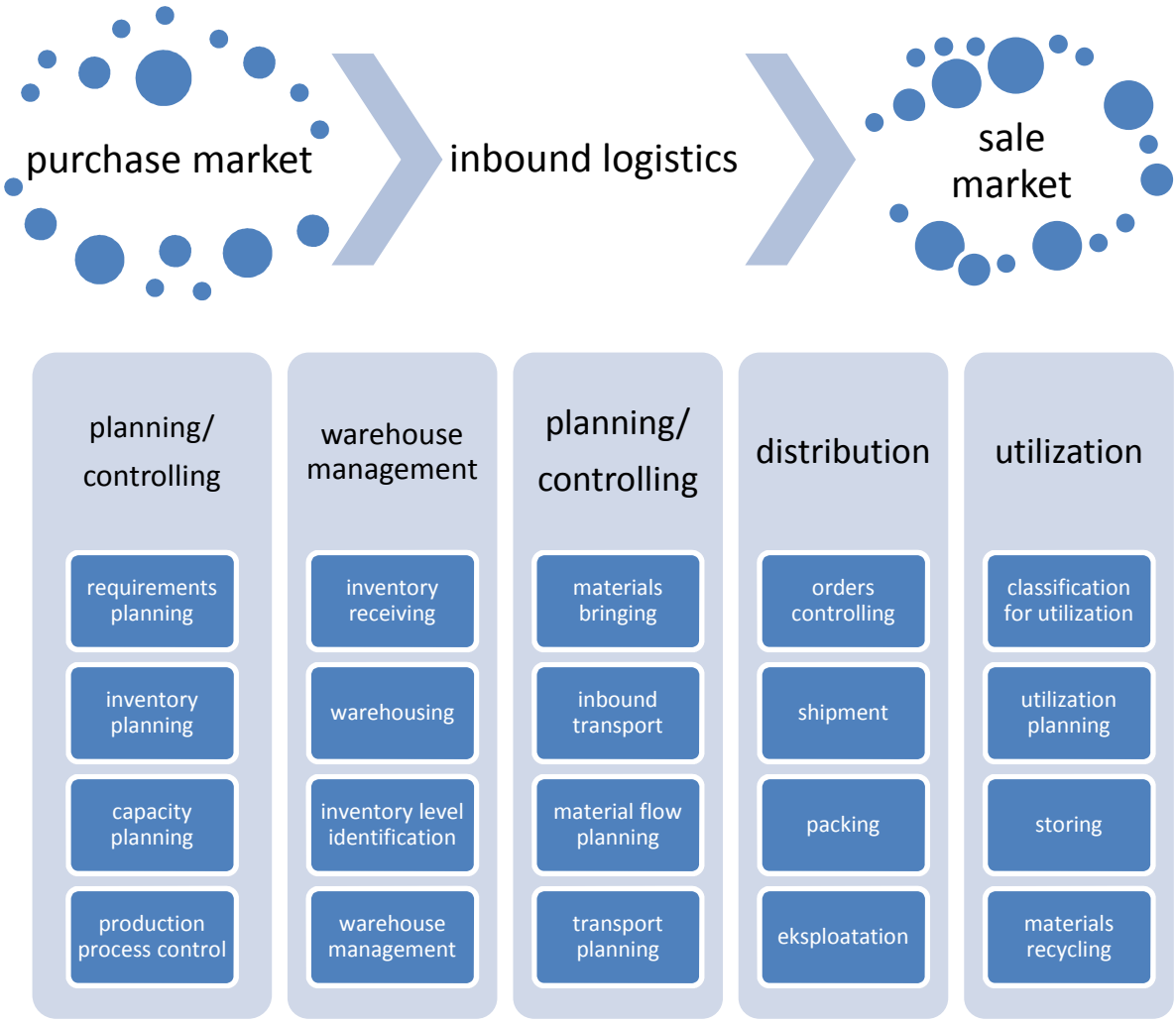
- Strategy of differentiated distribution - not all products should be provided with the same level of service market. Different customers require different characteristics of the product and the various forms of sales, for example, large customers can be supplied directly by smaller regional distribution centers and small retail networks;
- strategy of rationalization - a company offers numerous kinds of products to various customers, bearing various kinds of costs. However the principle "Let's sell everything (we are able to manufacture) to anyone (willing to buy it)" should not be applied. Repeated analysis of assortment, customers and costs is required to provide knowledge on costs and profits generated by customers and companies (Pareto rule 80/20 can be of great help here);
- consolidation strategy - combining actions to achieve return-to-scale effect, f.ex. in transportation area it is recommended to combine loads to benefit from decreased unit costs. In a warehouse consolidation of inventory enables decrease in a number of warehouses, providing ability to achieve the same customer service level at a lower level of inventory;
- delay strategy -- delaying the final shape of the product to one of the last stages in the production and distribution process, or delaying changes in the location of inventory, for example, if the manufacturer of cookers moves painting process from the factory to the distribution center, it can reduce inventories. Then, he can better customize the colors to the signals coming from the stores in a given market.
- Mixed strategy - combination of assumptions taken from various strategies.

Although pure strategies allow for economies of scale and are cheap in governance, mixed strategies often produce better results in the area of cost [Słowiński 2008].

Efficiency of the solution applied depends on meeting the following two conditions:

- Logistic strategy should be consistent with other functional strategies and altogether they should create optimal combination of operations in a company,
- Logistics strategy should embrace the entire range of company's activity, including:
  - Procurement area,
  - Production area,
  - Goods distribution area,
  - Recycling, remanufacturing, utilization areas,
  - Storing processes,
  - Transport processes,

and harmonize them all in logistic aspects as it is introduced in the figure 3 [Witkowski 1995].



Source: Witkowski 1995

Fig. 3. Range of corporate logistic strategy
Rys. 3. Zakres strategii logistycznej przedsiębiorstwa

Typology of logistics strategies can also rely on the approach of their users. Bowersox and Daugherty (1987) applied this approach, using in their research American manufacturing companies (from Fortune 500 list) benefiting from logistics strategy based on process orientation, market orientation and information orientation. In turn, McGinnis and Kohn (1990) in their study also based on an analysis of U.S. companies have identified four categories of logistics strategies depending on the size and intensity of integration and coordination of logistics activities (internal and external), later (1993, 2000) identifying three main categories of strategy (intense, balanced and distributed). Kohn et al. (1990) made the analysis on the same market and identified the following factors determining strategy: customer service, integration of IT market, coordination and efficiency, which led them to the conclusion that logistic strategies differ substantially on account of global strategy and environment characteristics. Other authors for their typologies employ market-focused characteristics, such as product value [Cooper 1993], assuming that products of high value are delivered to customers directly, while for those representing lower value distribution systems are built, hence empirical research offer numerous, though sometimes consistent approaches.

In literature there is also an approach present, in which the functional logistics strategy is a method or set of methods used to achieve a particular purpose. In this perspective, logistical strategies are ways of dealing with the construction and operation of the logistics system. They provide model solutions in planning the movement of materials, conducting distribution, forming relationships with suppliers and customers. They are specific procedures for the operation characterized with certain principles of implementation and evaluation. Under this utilitarian approach the following solutions are distinguished [Pfohl 2001, Stachowiak 2010]:

- The classic strategy, based on the creation of inventories and inventory management,
- MRP (Material Requirements Planning) method of material requirements planning , building the strategic approach based on balancing the needs and available resources, and then planning the purchase of supply of the required notice, to achieve the availability of materials and the liquidity of financial resources,
- JIT (Just in Time), a set of methods and techniques based on the flexibility of the available capacity (resulting from its structure, i.e. universal , mutually substitutable resources and time buffers)
- ERP (Enterprise Resources Planning), the extension of MRP for resources across the enterprise, complex and interdependent system of planning and balancing, benefiting from IT support and nowadays functioning as a software package with a defined standard,
- SCM (Supply Chain Management), i.e. strategies that go beyond the organizational framework of the company, including supply chains and networks , configured according to a specific criterion, the efficiency (cost orientation, lean management) or flexibility (customer orientation, agile management).

In this interpretation strategies identified are to be applied either in only one of the areas of logistics, but take into account its surroundings and circumstances, or there are also those that bind all functional areas of a company, and even go beyond, integrating supply chains and networks.

Thus, literature shows differentiated approach to logistics strategies, their typology and classification, and the present study is to provide material forming the basis for publications in the field of logistics, analysis and expertise in this field, as well as the starting point for a discussion of the existing paradigms and potential directions of change.

GENESIS OF LOGISTIC STRATEGIES

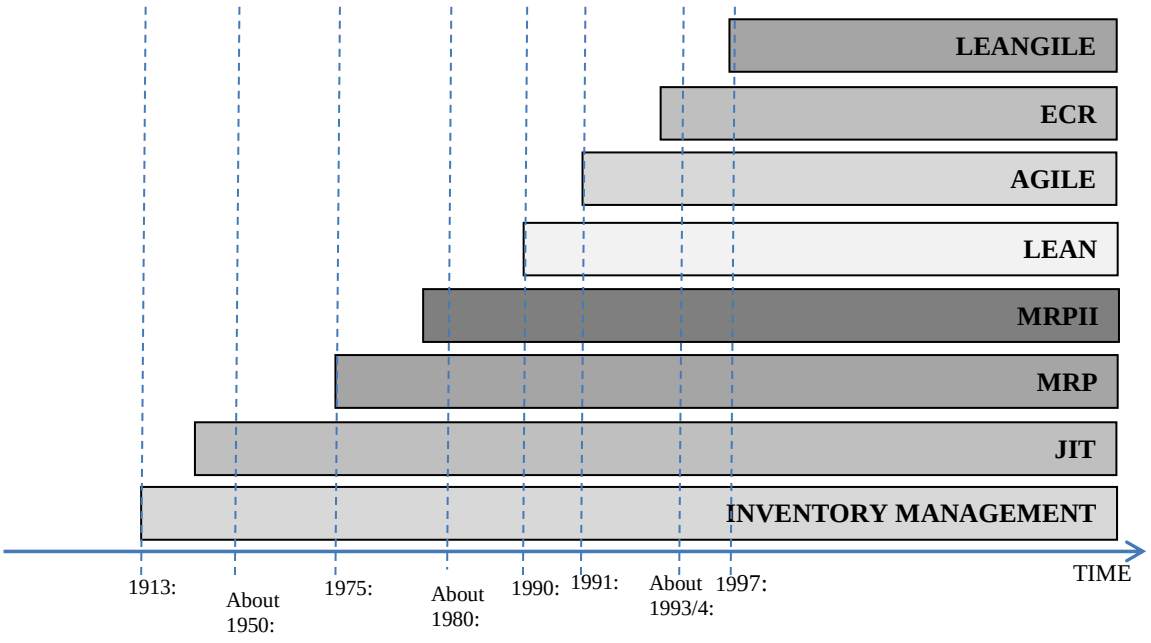
Characteristic of logistics strategies is that since they are defined, developed, they operate continuously in the market and are used by companies, so they do not disappear, but obviously the intensity of their use, represented by the number of implementation in organizations changes. Hence, it is impossible to reduce their use in time identifying the beginnings and the end, only identification of the point at which the solution appeared is possible, however it is sometimes difficult to clearly set a date for the appearance of the individual solutions, because certain approaches have evolved, paradigms, which represented, have changed gradually. Helpful in determining the age of logistics strategies are so called milestones in the development of logistics, usually in the form of projects or publications in which specific formulations, solutions, or terms they were first used. These include breakthroughs, such as:

- Ford's assembly line - solution introduced in 1913 in the Ford plant in Highland Park in the U.S. state of Michigan, has become a point of reference for the methods of mass production around the world, thereby forcing a specific organization of material flow - the creation of buffer inventory to maintain continuity of production [Pfohl 1995],
- Toyota Production System - Japanese solution, inspired by Ford's approach and supplemented by the establishment of eliminating waste policy, producing exactly on time (Just-in-Time), pull system, requiring synchronization of supply [Ohno 1995],
- ECR - Efficient Consumer Response - Effective Customer Service, solution introduced since 1993 (USA) / 1994

(Europe) by ECR Europe, aimed primarily aimed at streamlining and reducing the cost of customer service in the consumer sector by integrating the entire supply chain [Coyle 2002],

and publications:

- Material Requirements Planning, published in 1975 by Joseph Orlicky, the publication presents the essence of the MRP, with principles and guidelines of material requirements planning, approach to procurement, which is the essence of many of today's solutions in this field and an integral part of computer support systems;
- The Machine That Changed the World by James Womack, Daniel Jones and Daniel Roos, published in 1990 by MIT, presents the essence of lean manufacturing (lean production) , recognized as the biggest revolution since the Ford assembly line, forcing the integration of the environment through cooperation and coordination of the supply chain;
- 1991: The 21st Century Manufacturing Enterprise Strategy , developed by Roger Nagel and Rick Dove (Iacocca Institute) in 1991, a report on trends in the modern production and management , primarily customer orientation and flexibility in meeting its expectations and requirements , and customer integration into the flow of materials;
- Leagility : interfacing the lean and agile manufacturing paradigm in the total supply chain , in 1997 , in which the term leagility appears first, coined by J.B. Naylor , M. M. Naim and D. Berry and interpreted as a combination of agile and lean strategies; The term leagility since that time refers to a hybrid solution combining benefits from lean production paradigm and agile organization, coping with dynamic environment.



Source: own study

Fig. 4. Milestones in historical development of logistic strategies
Rys. 4. Kamienie milowe w historii rozwoju strategii logistycznych

Putting these "milestones" and related solutions to the timeline shows when various methods and strategies of logistics appeared, what are the ordinal relations between them (Fig. 4).

In addition to the milestones and key solutions for logistics strategies which these events initiated, in the diagram, there is also a solution which is an extension of a pre-existing one (MRP II - operating since the 80s of the twentieth century.) The continuity of the existence and use of the various solutions shows that none of them have been abandoned, although subjected to modifications and updates, moreover each solution introduced: a strategy or method enriched currently available composition of functional logistics strategies.

CHARACTERISTICS OF IDENTIFIED LOGISTIC STRATEGIES

Today, companies benefit from the whole spectrum of functional solutions within the logistics strategies, choosing them according to the global organizational goal, structure or expected results. The main differences in the above categories are presented in the table below.

The criteria taken into account in the table below are the purpose for which the solution has been developed, methods and tools used and the expected effects and consequences of, and generally scratched range. The method requires that the following conditions are met: planned selection and arrangement of the component activities united by a common goal, conscious and systematic in their use, the generality of the development allows for repeat steps whenever the need arises, the complexity of their activities. The term tool can be considered in two ways: a given method (or technique) can be used as a tool within the other, more complex methods, the method can be understood as a tool because of its simplicity and wide range of applications. Frequently used in the following classification: tool: the method easy to use and used in a wide range of methods in the context of more complex and while the band techniques: methods of teamwork and idea generation methods: methods that use complex tools and techniques. This table allows identification of the most important characteristics of the selected solutions - methods identified as functional logistics strategies.

Table 1. Comparison of logistic strategies
Tabela 1. Porównanie strategii logistycznych

Method/ logistics strategy	**Goal**	**Methods**	**Tools**	**Results**	**Range**
Classic strategy	Continuity of production, minimization of procurement costs, high customer service level	Creating inventory in various stages of material flow	Economic lot size, safety inventory, forecasting	Inventory distribution, capital freezing, high customer service level	A company
Material Requirements Planning (MRP)	Inventory reduction, Delivery cycle reduction	Material requirements planning, scheduling	Requirements scheduling, lot-sizing	Coordination of material requirements within dependent demand, cost reduction	A company
Manufacturing Resources Planning (MRPII)	Integration, improved efficiency	Internal integration, improved efficiency	Capacity balancing	Improved efficiency of functioning of a production system	A company
Just – in - time (JIT)	Waste elimination (time and inventory), efficiency increase,	Efficiency increase, waste elimination	TPS[1], rolling forecasting[2], kanban[3], time windows for deliveries, waste elimination (time and inventory)	Deliveries in time, team-work, cost decrease	A company

Method/ logistics strategy	Goal	Methods	Tools	Results	Range
Efficient Customer Response (ECR)	Increased efficiency of customer service, delivery time compression	Improved efficiency of material and information flows	QR[4], EDI[5], VMI[6]	Improved communication, decreased inventory level in a supply chain	A supply chain
Lean Management	Cost decrease, waste elimination	Focusing on core competencies, leaning processes	VSM[7], JIT, Open Book Management[8] and others applicable in Lean approach for supply chains[9]	Costs reduction, synchronization of material flows with demand,	A supply chain
Agile Management	Response to turbulent demand, meeting customers' requirements	Selection of resources and competencies of employees enabling them realization of processes according to customer requirements, modularization	QR, customization[10], modularization, agile intermodal transport in supply chains, EDI, tracking and tracing	Ability to meet various demands of customers	A supply chain
Leangile Management	Response to turbulent demand, cost decrease	Delayed response to market needs with proper location of decoupling point, modularization	QR, customization, proper location of decoupling point	Ability to meet various demands of customers at lower costs	A supply chain

Source: own work

1) Toyota Production System [Ohno 1995]
2) Rolling forecasting is systematically repeated, realistic anticipation of events, achievements and conditions of enterprise functioning in a given time horizon [Pawlak 2012]
3) Kanban - Kanban is a system to control the logistical chain from a production point of view, and is not an inventory control system. Kanban was developed by Taiichi Ohno, at Toyota, to find a system to improve and maintain a high level of production. Kanban is one method through which JIT is achieved [Ohno 1988] [Durlik 1996]
4) Quick Response, QR, strategy according to which sellers and buyers cooperate to respond to customers demand as fast as possible [ECRPolska]
5) Electronic Data Interchange, EDI, exchange of data in a standard format between IT systems of commercial partners at minimum human intervention [ECRPolska]
6) Vendor Managed Inventory, VMI Suppliers monitor inventory level in a warehouse of their customers basing on sales forecasts and sales data, maintaining and developing availability of products in supply chains [ECRPolska]
7) Value Stream Mapping, The process of defining value added to a product when it is being manufactured go. Mapping is based on going upstream, from the end to the beginning and presenting both material and information flows. It is also important to include the following information on needs, requirements and processes themselves with use of the parameters such as: C/T, C/O (changeover time), EPEI (every part every interval), available time, number of operators, etc. [lean-management.pl]
8) Open Book Management, approach in which it is necessary to provide employees with information enabling understanding of enterprise functioning, the term coined by Case in [Case 1995]
9) The reader will find more in: [Womack 90]
100 Customization is adjusting an element of marketing mix (price, product, place or promotion) to individual needs of customers [Newell 1997]

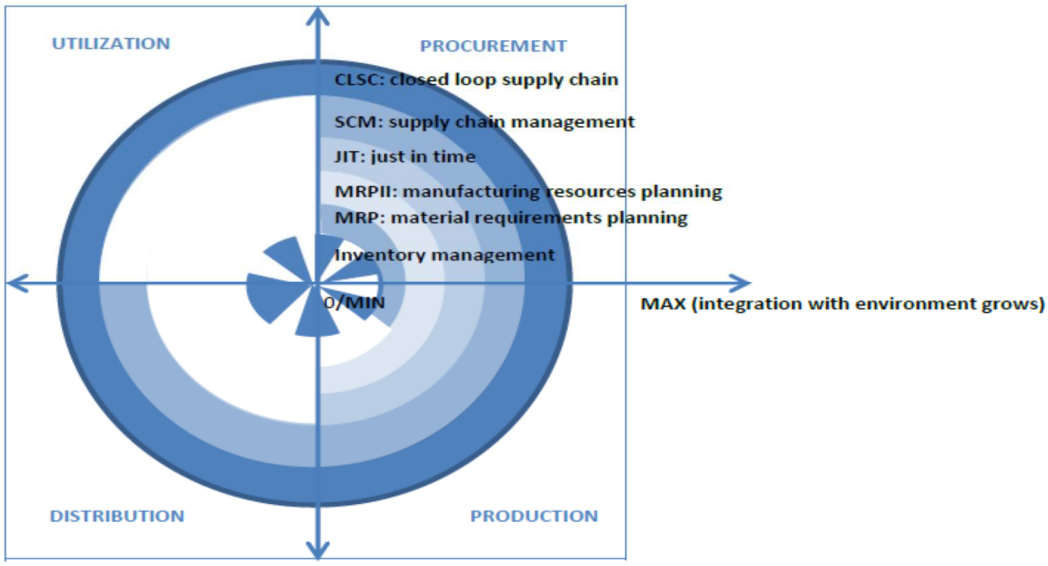
APPLICATION RANGE FOR PREDEFINED STRATEGIES

The strategies and solutions in their field differ with functional scope, the scale of influencing both the company and the surroundings. It may be noted that as the introduction of new solutions in the field of logistics strategies (presented in the previous section), i.e.:

- Inventory management,
- JIT,
- MRP,
- MRPII,
- SCM - Supply Chain Management, INCLUDING Agile, Lean, ECR, Leagile,

Progressed, their territorial scope increases, from the methods that apply to only selected areas of the enterprise, to the approaches integrating the entire supply chains or networks. The following figure shows the functional scope of the solutions used in the logistics strategies broken down into the following areas: supply, production, distribution and utilization. To take into account the increasingly important area of utilization, strategies list also includes closed-loop supply (Closed Loop Supply Chain),

incorporating to the classic supply chain, ending on the client and its service also an area utilization and processing (Remanufacturing) of exploited products.



Source: own study

Fig. 5. Range of application of logistic strategies
Rys. 5. Zakres stosowania strategii logistycznych

On the one hand, this approach has ecological orientation (reducing the amount of waste), on the other economic (saving resources), which makes it a sustainable strategy (based on the idea of sustainable development), also allowing to maintain continuity of contact with the client (the reader will find more in Krikke 2004 and 2005) (Fig. 5).

An additional dimension included on this chart is the degree of integration with the market, indicating a trend - the newest solution, the more it goes beyond the boundaries of the organization and strives to create chains, networks and supply loop. Hence, the idea of the figure is to show areas of application of predefined solutions (whether they are applicable in procurement, production, distribution or utilization area - or they go beyond one functional range striving for internal integration) and in the same time consider the level of external integration, with market environment (customers, supply chain partners and other stakeholders). The conclusion is, that the newer the solution, the broader its range (though inventory management refers to all the functional areas, it does not strive for integration, quite opposite, dispersion of inventories is recommended) and stronger integration with market environment. It is also important to take into consideration the fact that all of these solutions mentioned relate to the production area and the procurement area as well. Since in the area of production, logistics tasks, similar to the production strategies, include planning, coordinating and controlling the flow of materials to achieve specific system parameters - speed, economy of movement, continuity of material flows.

PRODUCTION STRATEGIES

Comparison of classical production strategy, MRPII [Heizer and Render 2007], Lean Production System [Womack et al. 1990] and a system based on Theory of Constraints [Schrangeheim et al 1990] reveals fundamental differences in the planning and organization of production flow in these concepts [Hadaś et al. 2010]. Also the QRM strategy (Quick Response Manufacturing) [Suri et al. 2010], despite its relations to ECR and Lean shows important differences compared to the generic solutions. The differences between the various

strategies found in the following issues (check the Table 2.):

- implementation of the core planning activities,
- organization and material flow management,
- organization of production and the selection of the product portfolio,
- buffering mode of variability in demand and process disturbances.

Table 2. Production strategies and planning methods
Tabela 2. Przegląd strategii produkcyjnych i metod planowania

Production strategies / **Category**	**Classic**	**MRP/ MRPII**	**LEAN Production**	**TOC (DBR Solution)**	**QR Manufacturing**
	Realization of basic planning actions				
Basic planning actions	Inventory replenishment	Capacity balancing	Capacity balancing	Flow balancing	Quick paths identification
Management centralization and decentralization	Global planning on product level. Inventory decentralization	Planning centralization. Inventory centralization in a decoupling point	Flow control decentralization (local control loops).	Planning focused on bottlenecks. Flow decentralization according to FIFO	Planning centralization. Flow control decentralization according to availability of production unit
	Material flow organization and management				
Flow type	Push	Push	Pull (Kanban)	Hybrid push/pull	POLCA
Flow initiation	On input	On input	On output	According to constraints	On the level of production unit
Operations order	Priorities	According to schedule	FIFO	FIFO + schedule for critical resources	Priorities
Accepted level of flow complexity	Average	High	Small	Average to high	Small
	Organization of manufacturing units and portfolio identification				
Production form	Continuous flow (tact based) or non-continuous flow	Continuous flow (tact based) or non-continuous flow	Continuous flow (tact based)	Continuous flow (tact based) or non-continuous flow	Continuous flow (tact based)
Workshop re-organization (layout)	Not required (varied flow)	Not required (varied flow)	Required (product orientation)	Not required (varied flow accepted)	Recommended (product orientation)
Assortment portfolio	High complexity, wide assortment and variety	High complexity , wide assortment and variety	Standardized products	Complexity accepted	Lots of options, low variety of assortment
IT suport for planning	Not required	Required (MRPII)	Not required	Not required	MRPII at planning level. Flow without IT support
	Demand variety and disturbances buffering				
Buffering	Inventory buffers (buffers between stages and workstations)	Time buffers for process stages execution and inventory buffers in decoupling points	Difference: Tact time and operation cycle	Extra capacity and time in non-critical and key resources, buffers between stages	Capacity inventories

Source: own study

The traditional production strategy is based on the paradigm of the economics of scale where the lot size is subject to economic evaluation and the number of changeovers is minimized. Large production runs generate long cycles and hence high WIP inventories, as well as inventory of finished products. Inventory cache interference in the production process but the flow is in large batches and most of the time is waiting for the treatment

(so-called batch and queue system). The strategy is based on identifying the location of the inventory in the system of production and logistics, optimization of their size and in consequence inventory replenishment. Hence, inventory is decentralized.

The MRPII strategy is a strategy of gradual planning and development of the idea of Material Requirement Planning (MRP I). The main idea is to combine independent demand (for finished goods) with the demand for components (dependent demand). The basic planning operation consists in the calculation of the material requirements and balancing production capacity at the levels of the product and components. Calculation of material requirements based on the structure of the product (called the Bill of Material) allows to limit the inventory at various levels of complexity of the product (by replacing the buffer time) and its concentration in the logistic decoupling point. At the same logistical point of separation (also called the order penetration point) can be positioned depending on the adopted strategy within customer service area, among others, in the warehouse of finished products, semi-finished products or raw materials.

The Lean Production strategy organizes the flow of material flows in order to achieve its continuity without queues and waiting for treatment [Liker et al. 2003]. In contrast to the traditional system, changeover is not the action avoided, but steps should be taken to minimize changeover duration by implementing well-known practices (SMED - Single Minute Exchange of Die or Single Minute Exchange or Die). The priority is to focus efforts on the elimination of waste (muda) [Ohno 1995], the most obvious manifestation is the accumulation of surplus inventory. In the lean system there are already steps taken at the design stage, which aim to balance the potential of the individual segments and make them productive machines. For this reason, the strategy requires the reorganization of the production unit (secretion of value streams and serving them specialized units responsible). The flow is more intense (without waiting for treatment), but the basis for the secretion of production units is the similarity of operations and range, and consequently its limited diversity.

Planning and control system based on TOC (Theory of Constraints) assumes batch variability with a general tendency to reduce them. Changeover process for machines is not treated as waste of time unless they relate to critical resources. Changeover of a critical resource is subject to strict limiting according to the assumption that inactivity of a critical resource is irreparable loss to the entire enterprise [Goldratt 1984]. The basic planning action is to balance the flow in order to maintain continuity of the bottleneck's identified work and control of the level of work in progress. Planning tool coordinate the flow with a critical resource is Drum - Buffer - Rope mechanism [Gardiner 1993].

Strategy for Quick Response Manufacturing (QRM) focuses its attention on shortening the total time of the contract (called Cumulate Lead Time) [Suri et al. 1998]. In the supply chain, the key is to provide the efficient flow of information from the customer to the supplier. On the other hand, on the level of production units this objective is realized by determination of the critical paths of orders (Manufacturing Critical-path Time - MCT), based on the standard critical path method (CPM). QRM strategy in many aspects is based on Lean Production, as its enrichment towards the direction of extension of the assortment and quantity of flexibility in terms of covering the demand. An example of such an extension is orientation of production units known from lean approach (Cellular Manufacturing) towards selected profitable market segments (Focused Target Market Segment - FTMS).

Further differences between production strategies can be found in the field of organization and management of material flows. According to the classic strategy material flow is initiated at the input to the system by issuing the material to the first workstation. Flow through next workstations is performed with push logic via the system until the final operation is completed. Such an organization of the flow is the reason for the large inertia of the system to the variability of assortment and low resistance to

interference, which generate an increase in inventories of work in progress. In the Lean Strategy flow is initiated at the last station and then by using kanban passed further up the value stream. "TOC" Strategy in terms of flow control is, however, a specific combination of "push" and "pull" logics [Hadaś et al. 2007]. Bottleneck operation is scheduled (so called drum) and the release of the material to production is initiated with a "pull" logic (so-called "rope" in a drum - buffer - rope method). On the other hand, the flow to specific workstation which are not "bottlenecks" is implemented by "push" logic according to the FIFO priority. QRM strategy controls the flow of materials with the mechanism which is an adaptation of a kanban tool. As used herein, the tool POLCA (Paired - cell Overlapping Loops of Cards with Authorization) [Krishnamurthy et al. 2009] implements the "pull" logic allowing to control work in progress . The main difference is that the signal to the flow realization is not the need for material like in kanban, but spare capacity of the production unit.

Due to the volume of the article the authors did not characterize all categories of analysis of production strategies distinguished here, instead focusing on the features associated with material flows the most.

CONSOLIDATION OF PRODUCTION AND LOGISTIC STRATEGIES ACCORDING TO ORIENTATION TO MULTI-VARIANT CUSTOMER SERVICE

Relationships between production and logistics are traditionally very strong. In the classical approach in the case of internal material flow they are associated with the logistic support of the production floor. On the other hand, in the case of external supply chains it is related to the logistics supplies of parts and raw materials, and distribution of finished products. Contemporary business process orientation on customer service has brought another aspect of closer links between the production and logistics. Logistics orientation of the production process at the time and level of customer service has a direct impact on strategies for planning and controlling the flow of material. Particularly strong similarities (between logistics system and production) should be present in the areas of planning [Fertsch 2010]. In turn, choice of logistics strategy and specific solutions adopted in the framework of the model of logistic system is derived from the organization of the flow of materials in the area. Today, logistics is the task of synchronizing the flow of goods in the manufacturing systems with their entry to and exit from the enterprise to create the best conditions for efficient production planning and controlling [Fertsch 2009].

In the table below (see Table 4), the authors make attempts to consolidate selected strategies for production and logistics according to multi-variant orientation on customer service. With other words these are actions taken to provide internal coherence of a group or a structure and to reinforce it, as well as the result state of the actions - integration.[Bralczyk 2005].

Table 3. Consolidation of production and logistics strategies according to orientation on multi-variant customer service
Tabela 3. Konsolidacja strategii produkcyjnych i logistycznych wg. orientacji na wielowariantową obsługę klienta

Category **Strategy**	**Planning** (on the level of products and parts)	**Controlling** (of material flows)	**Coordinating** (subject range in supply chains	**Customer-orientation** (focus on internal and external customers)	**Results measurement** (key measures and indicators)
Classic	Independent planning of inventories level for final products, parts and components, based on forecasted use (demand)	Decentralized inventory control Lots released based on economics (WIP vs. changeover sequence)	Inventories replenishment on various levels of value stream (aggregation of safety inventory for various needs and inventory localizations)	Make to inventory (MTS) at predefined service level. Inventory replenishment in supply chain (push) – availability providing (on hand)	- Customer service level - Inventory rotation - Work load for machines and employees

Category **Strategy**	**Planning** (on the level of products and parts)	**Controlling** (of material flows)	**Coordinating** (subject range in supply chains	**Customer-orientation** (focus on internal and external customers)	**Results measurement** (key measures and indicators)
MRP/ MRPII	Production planning based on orders and forecasts. Calculation of requirements for parts and components. Closed loop balancing. Potentially increased functions of planning – APS Advance Planning and Scheduling) [1]	Control on the level of parts scheduling and priorities for lots releasing, potentially increased with tracing the flow on a shop floor – MES Manufacturing Execution System	Coordination of supplies with supplies schedules. Coordination of distribution with DRPII (Distribution Resource Planning)[2]	Production according to decoupling point (order penetration point) dependent on lead time accepted by customers (CTLT – Customer Tolerance Lead Time)	- Orders on time - Conformity of schedules and their realization
LEAN /JIT	Leveling of production plan according to typical order sequences and capacity of a plant identified with a unit rhythm	Local control loops (kanban), optimization with assortment selection to value chain	Production plan forecasts (Rolling forecasting) distributed within supply chain Deliveries coordination with JIT and JIS (Just in Sequence)	Customer service buffering with inventories, replenishment in supply chain with pull logic	- Cost - Lead Time - Value added
TOC /Continuous replenishment (TOC distribution solution)	Bottlenecks load planning at final products level. Machine load planning with respect to continuity of bottleneck work (max. use)	Non-critical resources subordinated to bottleneck work pace Flow according to FIFO with monitored use of bottleneck buffer	Coordination with Drum-Buffer-Rope mechanism at the level of an enterprise. Replenishment at the level of a supply chain (Traffic Light Analogy)[3]	Customer service buffering with inventory and/or time. Inter-stage buffers dependent on complexity of material flows (VAT - Analysis) [4]	- Throughput - Inventory - Operating Expense (TOC Accounting)
ECR/QRM	Planning based on demand forecasts and orders coming from supply chain. ERP planning for final products level	Local control loops (POLCA). Optimization with resources use and Lead Time reduction	Efficient flow of information in a supply chain. Coordination of tasks with information on actual demand (flow in a value stream).	Orientation of profit bringing customers groups and providing them with fast reaction time or high service level (inventory availability)	- Complete lead time - Customer service level - Orders on time - Inventory rotation - Key resources utilization
Agile	Planning on the level of product families and modules with use of increased ERP functionalities. Project planning for new products according to (Scrum)[5] - *Release Burndown* methodology	Production streams flow planning (Sprint Planning), selecting tasks of highest priorities (Flexible resources use)	Agile logistics – logistics coordinates manufacturing and supplies within supply chain creating - *Coupled Dynamic System*	Customer service buffering with inventories or quick response to requirements Dynamic flow and resources management	Indicators defining multi-dimensional ability to change and cost of change: - FAI (Fuzzy Agiity Index)[6] -Due-date performance -Difficulty of adhe-ring to schedule of production - Capacity Utilization - (Cost of Excess capacity) - % of order delivered according to plan - Supply chain response time. - Cash-to-cash cycle time

Source: own study

1) APS - Advance Planning and Scheduling - a class of advanced IT systems which are based on ERP standard but increased with opportunity of complex planning, simulation and optimization [APICS 2008]

2) DRPII - Distribution Resource Planning - DRP increased with planning requirements to crucial resources in supply chains, i.e. warehouse space, means of transport etc. [APICS 2008]

3) Traffic Light Analogy the technique for inventory level monitoring with use of three buffer zones. Check the practical example in: [Cyplik, Hadaś, 2012]

4) VAT - Analysis is the method of classification of enterprises with material flows topography. Check the practical example in: [Hadaś , Cyplik, 2013]

5) Measures used in agile project management (Scrum)

6) Expert assessment based index developed in [Lin 2003]and applied with some changes in [Stachowiak 2004]

The analysis of production and logistics strategy has enabled their aggregation in order to demonstrate their consistency in the development of internal and external supply chain. Undoubtedly the principal platform for aggregation manufacturing and logistics strategies is the approach to manage the flow of material streams i.e. its organization, planning, and control.

DEFINITION OF PRODUCTION AND LOGISTICS SYSTEM

On the basis of the above considerations, the authors of the article formulated definition of production and logistics system as an object of modeling in the transformation of business systems of manufacturing companies.

Production system can be defined as by Eversheim (1992) as an "independent allocation of potential and resource factors for production purpose", which in addition to the elements of the technical production process, also includes organizational elements for the planning and controlling of the production process. Accordingly, it has a specific system organization that creates specific links between the elements of a production system in order to achieve the optimal factors combinations to complete the task [Kern 1980].

A production system comprises a number of elements between which there are reciprocal relations. Commonly mentioned elements are premises, humans, machines, and equipment [Löfgren 1983]. Software and procedures might be added to the listed system elements according to [Chapanis 1996]. A structural perspective of a production system can be used to describe the different system elements and their relations.

Logistics activities in manufacturing companies can be divided into three fields: procurement logistics (in-bound), production logistics (in-plant) and distribution logistics (out-bound) [Baudin 2004].

The activities of production logistics are from dock to dock, meaning all activities from the receipt of goods to the dispatch. Its main purpose is to offer an efficient logistical support for production through material planning, i.e. planning, execution and control of material flows [Bullinger et al. 1994].

Hence, efficient production logistics secures minimal inventory levels, short lead times, high flexibility of production and consistent (internal) customer orientation. Synchronization, flow and tact orientation, as well as the consideration of customer needs, are key requirements for eliminating wastes in form of excess inventory or waiting times due to material shortages [Droste et al. 2012].

Based on presented in this article deliberations the authors assume that production-logistics system is constructed as a set of elements of a production system, composed of premises, humans, machines, and equipment, software, procedures and the decision-making process, linked by mutual interrelations with a view to executing a logistics strategy.

ACKNOWLEDGMENTS

This paper has been the result of the study conducted within the project entitled "Multifaceted research the determinants of transformation of the production and logistics system with diversified production structure, wide product offer and multivariate strategy for customer service" realized in the Faculty of Engineering Management of Poznan University of Technology. The project was financed by the National Science Center based on the decision number DEC-2011/03/B/HS4/04125.

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SYSTEM PRODUKCYJNO-LOGISTYCZNY W KONTEKŚCIE STRATEGII PLANOWANIA I STEROWANIA PRODUKCJĄ ORAZ LOGISTYCZNEJ OBSŁUGI KLIENTA

STRESZCZENIE. **Wstęp:** Autorzy dokonali wielowymiarowego przeglądu strategii produkcyjnych i logistycznych w celu wykazania ich spójności w kształtowaniu wewnętrznego i zewnętrznego łańcucha dostaw. Artykuł kończy sformułowanie definicji systemu produkcyjno-logistycznego jako obiektu modelowania w transformacji systemów biznesowych przedsiębiorstw produkcyjnych.

Metody: Artykuł oparto o analizę literaturową strategii produkcyjnych oraz logistycznych. Przeanalizowano wybrane kluczowe publikacje związane z genezą powstania strategii oraz podstawowych założeń ich funkcjonowania. Syntezę porównawczą strategii logistycznych i produkcyjnych dokonano na podstawie doświadczeń autorów w kwestii zastosowania wybranych narzędzi i metod charakterystycznych dla omawianych strategii.
Wyniki: Rezultatem prac jest konsolidacja strategii produkcyjnych i logistycznych zgodnie z orientacją na wielowariantową obsługę klienta oraz autorska definicja systemu produkcyjno-logistycznego.
Wnioski: System produkcyjny i system logistyczny można traktować jako równorzędne elementy w kontekście zarządzania przepływem strumieni materiałowych w wewnętrznych i zewnętrznych łańcuchach dostaw. Tak określone podejście pozwala modelować oba systemy jako spójne elementy realizujące wybraną strategię obsługi klienta.

Słowa kluczowe: MRP, Lean, TOC, Agile, ECR, Quick Response, SCM, system produkcyjny, system logistyczny

STRATEGIEN FÜR PRODUKTIONSPLANUNG UND -STEUERUNG UND FÜR DIE LOGISTISCHE BEDIENUNG DER KUNDEN

ZUSAMMENFASSUNG. Einleitung: Die Autoren haben eine multidimensionale Übersicht von Strategien für die Produktionsplanung und -steuerung zwecks Ermittlung deren Zusammenhangs bei der Ausgestaltung der inneren und äußeren Lieferkette vorgenommen. Der Artikel wird mit Formulierung einer Definition des produktionslogistischen Systems als eines bei der Transformation von Business-Systemen in Produktionsunternehmen wirksamen Modellierungsobjektes abgerundet.
Methoden: Die Forschung stützte man auf die Literaturrecherche im Bereich der Planungs- und Steuerungsstrategien in der Produktion. Die im Zusammenhang mit der Genese der Entstehung von Strategien und der Grundlagen ihrer Funktionsausübung stehenden Schlüsselveröffentlichungen wurden einer tiefeingehenden Analyse unterzogen. Die betreffende Vergleichsanalyse von logistischen und Produktionsstrategien wurde auf Grund von Erfahrungen der Autoren in Bezug auf die von ihnen in Anspruch genommenen Werkzeuge und auf die ausgewählten, charakteristischen für die betreffenden Strategien Methoden ermittelt.
Ergebnisse: Das Resultat der Arbeit besteht in der Konsolidierung der logistischen und Produktionsstrategien gemäß der Orientierung auf variantenreiche Kundenbedienung und der durch die Autoren ausgearbeiteten Definition des produktionslogistischen Systems.
Fazit: Produktionssysteme und logistische Systeme kann man als gleichwertige Elemente im Kontext des Managements von Materialflüssen innerhalb der inneren und äußeren Lieferketten behandeln. Das so ermittelte Herangehen an die Thematik lässt die beiden Systeme als die zusammenhängenden und die die ausgewählte Strategie des Kundenservices realisierenden Elemente modellieren.

Codewörter: MRP, Lean, TOC, Agile, ECR, Quick Response, SCM, Produktionssystem, logistisches System

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