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LOGISTICS MATURITY MODEL FOR ENGINEERING MANAGEMENT – METHOD PROPOSAL

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Abstract:
The objective of the paper is to present results of research carried out on the development of a logistics maturity model for enterprises. The proposed approach allows for companies to self-assess their level of advancement of logistics processes implementation with the use of logistics maturity model. Considering the results of the assessment, directions for further actions may be determined. The proposed model comprises three dimensions: SCOR model, phases of the industry logistics and logistics tools, what makes it original approach in the field of logistics maturity research. Moreover, the model described in the paper is dedicated for service industry, which is in research niche. The current state of research on maturity models is reviewed to serve as a basis for the model developed in the paper. There are inlcuded theoretical assumptions of the proposed logistics maturity model and presentation of the model's concept, considering directions for future research on the specified issue.

Key words: *logistics maturity model, engineering management*

INTRODUCTION

The concept of *Engineering Management* has been existing among academia and practice for several decades. Considering results of literature review on the definition of this concept, it was claimed, that genesis of the presented concept should be seen in the precursors of management such as Frederick Taylor, Henri Fayol, and Henry Gantt [1]. The definition of the *Engineering Management* concept has coevolved with change in the approach to management, in general. Currently, in the field of research on Engineering Management, there may be observed a trend in treating this primarily in the educational dimension as the name of the course for future managers. It is confirmed by the number of publications in the *Web of Science* and *SCOPUS* databases, what is presented in the Table 1.

Table 1
Results of the literature research conducted on engineering management in the selected databases on 22.05.2018

Keywords	Database	Search fileld	Time	Number of results
„Engineering management"	Web of Science	Title	No limits	575
	Scopus			978
„Engineering management" + Education	Web of Science			60
	Scopus			74

As a consequence of the revision made on the engineering management term, it was claimed, that this concept is not clearly defined. Following M. Fertsch, it was stated that engineering management is derived from development of production engineering [2]. Considering that, authors propose their own definition of this concept. With reference to the definition of production engineering, authors suggest treating the engineering management as:
"a scientific discipline belonging to engineering science and management science, which deals with analyzing processes carried out in enterprises, mainly industrial ones, and designing some methods for process effectiveness improvement. Engineering management is based on the concept of system approach".
Engineering management is also reflected in the logistics, what is expressed through logistics engineering, that is expressed by applying the achievements of technical sciences in the field of logistics. The major objective of the paper is to present the concept of a logistics maturity model as a method, which allows companies to self-assess their level of advancement of logistics processes implementation with the use of logistics maturity model. Considering the results of the assessment, directions for further actions may be determined. In the authors' opinion, the proposed logistics maturity model may be considered as a modern and innovative method of enterprise management. However, a prerequisite for the practical implementation of this method is to treat logistics as a business management concept. As it was pointed out by A. Mazur et al., the necessity to identify and to search for the critical success factors of enterprises resulted in the increase of

the logistics management relevance, and its participation in business management [3]. Nowadays, logistics is used as a key factor for business success or key competence.

LOGISTICS MATURITY MODEL – STATE OF ART

On the basis of literature research on the specified issue, it was stated that, the logistics maturity model proposed in the paper adressed the research gap, in this area. In order to confirm that, authors refer to research carried out by A. Kosieradzka and J. Smagowicz, that were aimed to analyze maturity models applied in various areas of management, both in business organizations and administration [4]. In [4] authors analyzed 20 models of maturity from seven management areas, including: process management, production management, project management, software development management, administration management, quality management as well as risk management and business continuity. This confirms the lack of a maturity model in the field of logistics. There are studies involving models of process maturity in the field of logistics processes, however they concern application of general models of process maturity with reference to logistics processes. The existence of a research gap in the field of logistics maturity model is also stressed by scientific publications in specified research field. As part of the presented preliminary research, there was conducted literature research on the concept of logistics maturity. There were used *Web of Sience* and *Scopus* databases with search strings including keywords: "logistics maturity" and "logistisc maturity model", without time limits, written in English. The results of the reserach are presented in the Table 2. Considering data presented in the Table 2, it was stated that there is lack of comprehensive research on logistics maturity model development, what results also in deficiency for the definitione of „logistics maturity" term. There was identified only one research related to the issue of the Logistics Maturity Model. Following definition developed by Battista et al. [5, 6], in the presented paper, the logistics maturity is defined as:

"an organizational level of the company, indicating the extent to which logistics engineering is used in the areas of planning, procurement, storage, delivery and returns."

Table 2

Results of the literature research conducted on logistics maturity and logistics maturity model, on 22.05.2018

Keywords	Database	Search fileld	Time	Number of results
„Logistic Maturity" OR „Logistics maturity"	Web of Science	Title	No limits	0
	Scopus			3
„Logistics maturity model" OR „Logistic maturity model"	Scopus			1 [6]
	Web of Science			0

LOGISTICS MATURITY MODEL FOR ENTERPRISE – THEORETICAL BACKGROUND

The Logistics Maturity Model for Enterprise (LMME) developed in the paper, comprises three pillars:

- Pillar I: phases of industry logistics evolution & SCM,
- Pillar II: areas of logistics activities within enterprise according to SCOR model,
- Pillar III: logistics tools.

In the next subsections there are presented assumptions made on pillars of LMME, resulting from literature review and authors' experience and their observations.

Stages of industry logistics evolution & SCM

So far, there have been made a lot of research on development/evolution of industry logistics (e.g. [6, 7]). As a result of literature research aimed at providing information about stages of industry logistics, it was claimed that there is no one adopted statement in terms of periodization and nomenclature of individual stages of evolution's stages, particularly in its initial phases [9]. In recent years, P. Blaik has attempted to systematize phases of the logistics concept development [10]. Following R. H. Bailou, as the most adeqate research, there were specified the following stages of industrial logistics development, presented in Table 3.

Tabela 3

Stages of industry logistics development

Period of time	to 1960s	to 1980s	1990s	2000s	21st century	Future
Feature	Fragmentation	Consolidation	Functional Integration	Value adding	Globalization	Automation
Typical activities	Demand Forecasting Resources Planning Sourcing/Purchasing Warehousing Inventory Make to stock Internal Transport Packaging Distribution Planning Customer Service Transport Order Processing	Material flow Management Physical distribution	Logistics management 3PL BRP	SCM 4PL Eco logistics Sustainability	Lean SCM SCN GSC e-commerce	Industry 4.0 Internet of Things

Source: own elaboration on the basis of [9].

With reference to data presented in the Table 3, it is noteworthy that in comparison to traditional approach to logistics development phases (till 2000), researchers have included two additional stages – related to Internet development and its accessability, which has been considered as a result of looking for possibilities of operational costs of logistics processes reduction. This phase manifests itself above all in the popularity of e-commerce. The Internet use has influenced globalization effect, what is also characteristic feature of described stage.

Future – the last phase, which in practical terms is the unknown future, however not distant, which results from the development of automation and robotics. It is era of Industry 4.0 and the Internet of Things (IoT). Currently, manufacturers have already entered this phase, but it is still a far-reaching approach to widespread use, mainly due to the high costs of process automation and robotics. In authors' opinion, in the field of IoT, there have been already widely used many solutions, especially in trade and marketing.

Noteworthy, is also the development of a so-called SCM phase. It should be noticed that, on the turn of the 20th and 21st centuries, there have been commonly used pro-ecological approaches in logistics and thinking in terms of sustainable development category. It was claimed, that there have been made a lot of efforts on ecologistic and sustainable development within the framework of the industry logistics in that period.

Areas of logistics activities within a company

In the proposed model, authors moved away from well-known models of maturity, referring to the process or organizational approach. Foundations of process maturity models are not desputed in the paper, however authors' objective was not to develop a process maturity model in the field of enterprise logistics. The major purpose of the research was to determine the model in a broader context, which would go beyond the process approach and that will allow self-assessment of company's logistics maturity. Therefore, the particular logistics processes are not assessed in the model in contrast to areas of logistics activity, which are evaluated.

In order to determine the logistics areas of activities in enterprises, there were used reserach findings of other researchers on the Logistics maturity model. Battista et al. [5] adopted SCOR model as a foundation for logistics areas of activities in their model. As a result processess analized by them were divided into 4 areas. Following Battista et al. [5] there were included areas of Logistics activity, follwoing findings in the Table 4. With reference to Table 4, it should be noticed that, in the model presented in the paper, the Return area, which refers to reverse logistcis activities, will be analyzed. This becomes extention of research carried out by Battista et. al. [5].

Table 4

Areas of logistics activities in LMM

SCOR	LMM according to Battista et al. [5]	LMM	Description
Plan	Plan	Plan (P)	Processes about demand planning
Source	Source	Source (S)	Processes about procurement planning, identification and selection of the suppliers and procurement orders management
Make	Storage	Inventory/Storage(I/S)	Processes about stock management, in/out warehouse flow control, storage areas management and transport management of goods
Delivery	Distribution	Distribution (D)	Processes about shipment planning and transport management
Return	N.A.	Return (R)	Process about reverse flow planning, collecting, recovering and redistributing

Source: [13].

Logistics tools

In the research on LMM, it was assumed that the level of logistics maturity achieved by the company depends on the logistics evolution phase of the enterprise. Consequently, in order to determine phase of the logistics evolution, a measurement is necessary. Therefore, the use of logistics tools, which are widely known and used in manufacturing enterprises have been adopted to measure the logistics evolution phase of company under study. For this purpose, the authors used the list of the 100 most popular logistics tools proposed by G. Richards, S. Grinsted [11], what has been supplemented by 11 elements added by authors of the paper. As a result, a list of 111 logistic tools was created, which in the opinion of authors of the paper may be used by companies during logistics processes undertaking. The tools were divided into 10 groups, as shown in Table 5.

Table 5

Logistics tools in LMM

Group of logistics tools	Number of tools
01 Warehouse management (WM)	21
02 Transport management tools (TM)	13
03 Inventory management tools (IM)	19
04 Supply chain management tools (SCM)	23
05 General management tools (M)	10
06 Performance management tools (PM)	7
07 Financial management tools and ratios (FM)	5
08 Problem-solving tools (PS)	4
09 IT tools (IT)	12
10 Eco-tools (ECO)	N/A
Total	**111**

Table 6
Toolkit for LMM – examples

No	Logistic tool	Group	Tool's ID
1	Pareto analysis /rule, ABC analysis or the vital few analysis	**01 Warehouse management (WH)**	WH01
2	Selecting warehouse storage equipment		WH02
3	Selecting warehouse material handling equipment (MHE)		WH03
16	Calculating road freight transport charges and rates	**02 Transport management tools (TM)**	TM01
17	Transport management system (TMS) selection process		TM02
18	Transport problems – matching customer demand with supplier capacity		TM03
22	ABC Pareto analysis for inventory management	**03 Inventory management tools (IM)**	IM01
23	Cycle counting or perpetual inventory counting		IM02
24	Replenishment order quantities		IM03
40	Demand forecasting	**04 Supply chain management tools (SCM)**	SCM01
41	Supplier relationships		SCM02
42	Calculating ordering cost		SCM03
51	Flow charts	**05 General management tools (M)**	M01
52	Gantt charts		M02
53	SWOT analysis		M03
58	SMART	**06 Performance management tools (PM)**	PM01
59	Performance measurement and quality improvement		PM02
60	Performance measures for freight transport		PM03
64	Activity-based costing (ABC) and time-driven activity-based costing (TDABC)	**07 Financial management tools and ratios (FM)**	FM01
65	Supply chain financial ratios and metrics		FM02
66	Cause and effect analysis, or fishbone or Ishikawa	**08 Problem solving tools (PS)**	PS01
67	The 5Whys		PS02
68	Brainstorming		PS03
70	EDI	**09 IT tools (IT)**	IT01
71	RFID		IT02
72	Purchasing by internet		IT03
	Any one	**10 Eco-tools (ECO)**	ECO

At presented stage of research, there were not defined tools for the group no 10 – Eco tools. This aspect is the subject of other research conducted parallel by the authors of the paper. The proposed LMM model will be extended to eco issues after research ends. It is remarkable, that presented list of logistics tools used in the LMME is not closed and can be developed or modified on the basis of future research or by other researchers.

An exemplary list of logistics tools used in the research is provided in the Table 6. The full list may be found in [11].

The presented concept of logistics maturity level measurement with the use of logistics engineering tools is a derivative of research conducted by M. Fertsch on the place of logistics engineering in the Logistics development [12].

LOGISTICS MATURITY MODEL – CONCEPT

On the basis of the assumptions regarding three pillars, which have become foundations for LMM, the concept of the model was developed, including following steps:

- Step 1: Logistics maturity levels were defined based on the phases of industrial logistics development,
- Step 2: The areas of the SCOR model were assigned to the logistics tools,
- Step 3: The logistics evolution phases in the LMM were assigned to the logistics tools, considering the following principle: a tool is assigned to the phase in which it was used in practice,
- Step 4: LMM was developed.

The developed LMM concept is presented in the Table 7.

In the proposed model, there were defined four assumptions resulting from each other, what is presented in the Fig. 1.

Table 7
Logistics Maturity Model – LMM

Logistics Maturity Model for Enterprises – LMM

Stage of industry logistics development		Area of logistics activity	No of tools	Tool's ID	P'sIID
No	Name	LA			
		P	1	SCM01	1
		S	2	SCM02, SCM03	2
1	**Fragmentation**	I/S	5	WH01, WH02, WH03, WH04, WH16	4
		D	1	TM01	1
		R	0		0
		P	7	SCM05, M02, PM01, FM01, FM03, FM04, FM05	5
		S	3	SCM04, M03, PM01	2
2	**Consolidation**	I/S	15	WH05, WH17, IM06, IM07, IM08, IM09, IM10, IM11, IM12, IM19, M01, M03, PM01, SCM13, SCM19	11
		D	13	TM02, TM03, TM04,TM07, TM08, TM09, TM10, TM11, TM12, TM13 M01, M03, PM01	10
		R	3	M01, MO3, PM01	2
		P	13	SCM06, SCM07, SCM17, SCM20, M04, M05, M06, M08, M09, M10, PM02, PM04, FM02	10
		S	10	SCM09, SCM14, SCMM04, M05, M06, M08, M09, M10, PM02, PM04	8
3	**Functional Integration**	I/S	20	WH07, WH08, WH09, WH10, WH11, WH12, IM13, IM14, IM15, IM16, IM17, IM18, M04, M05, M06, M08, M09, M10, PM02, PM04	15
		D	8	M05, M06, M08, M09, M10, PM02, PM03, PM04	6
		R	5	M04, M05, M06, PM02, PM04	4
		P	5	SCM10, SCM22, M07, PM05, PM06	4
		S	4	SCM12, SCM18, PM05, PM06	3
4	**Value adding**	I/S	8	WH14, WH15, WH18, WH20, PM05, PM06, IT01, IT02	6
		D	5	TM06, M04, PM05, PM06, IT05	4
		R	8	TM05, M04, M08, M09, M10, PM05, PM06, WH19	6
		P	2	WH15, SCM11	2
		S	2	IT03, IT06	2
5	**Network Globalization**	I/S	1	IT06	1
		D	2	IT04, IT06	2
		R	1	SCM11	1
		P	9	IT07, IT08, IT09, IT10, IT11, IT12, M08, M09, M10	7
		S	9	IT07, IT08, IT09, IT10, IT11, IT12, M08, M09, M10	7
6	**Automation**	I/S	9	IT07, IT08, IT09, IT10, IT11, IT12, M08, M09, M10	7
		D	10	SCM08, IT07, IT08, IT09, IT10, IT11, IT12, M08, M09, M10	8
		R	9	IT07, IT08, IT09, IT10, IT11, IT12, M08, M09, M10	7

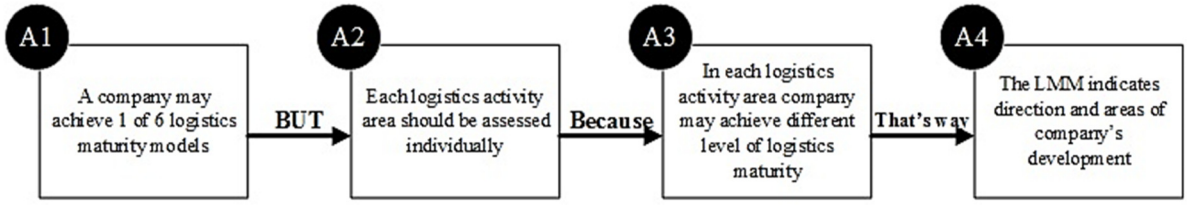

Fig. 1 Assumptions of the LMM
Source: [13]

In order to assess the company using the presented model (LMM), there should be made a diagnosis of logistics tools used by the company. It is reccommended to make a diagnosis through verification in the 0-1 system, considering elements of Boolean algebra, where:

- 0 means that the considered logistics tool is not used in the surveyed enterprise,
- 1 means that the company uses the specified tool.

The level of logistic maturity achieved by the surveyed enterprise depends on tools used by company under study. However, as the *P'sIID - Practices implementation indicator*[1] *was defined as:*

$$P'sIId \geq 75\%$$

It means that at least 75% of the tools that can be used at a given level of maturity, in a given area of logistics activity, however they have to be practically used by a company. Referring to the assumptions made on LMM (Fig. 1), it should be noted that according to the presented concept, the proposed LMM does not presume a comprehensive unambiguous assessment of the company's logistics maturity. It guarantees the assessment of maturity in each of the proposed areas of logistics activity, such as Planning, Sourcing, Inventory/Warehousing, Distribution, Return. In the authors' opinion, the adopted assumption is correct, because in various areas of logistics activity, enterprise may achieve different levels of logistics maturity.

Assessing and analyzing each area separately allows to distinguish specific areas, where maturity is not at the desired level. It is noteworthy, that the overall assessment at the company level would make it impossible to find areas of company's activities with problems, so the presented approach is reasonable, in authors' opinion.

SUMMARY

To sum up, it was stated, that the LMM presented in the paper has got conceptual and original nature, what becomes a result of literature research conducted by authors of the paper on logistics maturity in enterprises. In authors' opinion, the proposed logistics maturity model may be used by enterprises as a method of managing the company's logistics activities. It was stated, that the major benefit from the approach proposed in the paper, is a knowledge about company's logistics maturity level in particular research areas. It may result in focusing improvements activities on logistics operations requiring higher maturity level. In authors's opinion, higher level of logistics maturity in each area of logistics activity is equal to geater competitiveness of the service company, which is an element of a supply chain. In particular, it becomes relevant when it is about companies offering logistics services including: tranport, wrahousing, etc. Processess carried out by logistic operators with the use of logistics tools have an impact on efficiency of the entire supply chain.

Considering that, approach adressed in the paper is valuable in practical context. Due to the logistics engineering tools, which are used in the model, the method should be included in the methods of engineering management.

Within the scope of research carried out by the authors of the paper, there will be used a modified version of the LMM in terms of the list of logistics tools, that will be used in research on logistics maturity level in services sector, in Poland. The directions for further research also indicate the need to expand the model with logistics strategies implemented by enterprises. With respect to that, it was made a research hypothesis, indicating that there is a correlation between the logistics strategy applied by the company and the level of logistics maturity that the company achieve in a given area.

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REFERENCES

[1] D.A Meija, P.S De Leon. *Engineering Management*. Rex Book Store, 1997, p. 2.

[2] M. Fertsch. ''Production engineering and management engineering, their Genesis, todays's conditio and prospects of further development'' in *Ergonomia – Technika i Technologie – Zarządzanie,* M. Fertsch Ed., Poznan: Publishing House of Poznan University of Technology, 2009, pp. 169-178.

[3] A Mazur, K. Ligier, R. Prusak. "Aspekty logistyczne w ocenie dojrzałości organizacyjnej", *Logistyka,* vol. 6, pp. 12305-12309, June.2014.

[4] A. Kosieradzka, J. Smagowicz. "Analiza porównawcza modeli dojrzałości organizacji" in *Współczesne koncepcje zarządzania publicznego. Wyzwania modernizacyjne sektora publicznego*. M. Jabłoński, S. Mazur, M. Ćwiklicki, Fundacja GAP, 2016, pp. 283-296.

[5] C. Battista, A. Fumi, M.M.Schirald. "The Logistics Maturity Model: guidelines for logistic processes continuous improvement", in *Proceedings of the XXIII World POMS Conference*, 2012, pp. 1-18.

[6] C. Battista, M.M. Schiraldi. " The Logistic Maturity Model: Application to a Fashion Company". *International Journal of Engineering Business Management Vol. 5 Special Issue on Innovations in Fashion Industry 29:2013,* pp. 1-11, Jan. 2013.

[7] B.S. Blanchard. *Logistics Engineering and Management 6th ed*. USA: Pearson Education Hall, 2004, pp. 1-45.

[8] G.D. Taylor (ed.). *Introduction to Logistics Engineering.* USA*:* CRC Press, 2009, pp.1-14.

[1] Practices are considered as tools form the list of logistics tools in LMM appropriate for each logistics maturity level.

[9] R.H. Ballou. ”The evolution and future of logistics and supply chain management”. *European Business Review*, vol. 19(4), pp. 332-348, July. 2007.

[10] P. Blaik, A. Bruska, S. Kauf, R. Matwiejczuk. *Logistyka w systemie zarządzania przedsiębiorstwem*. Warszawa: PWE, 2013

[11] G. Richards, S. Grinsted. *The Logistics and Supply Chain Toolkit. Over 100 Tools for Transport. Warehousing and Inventory Management 2nd ed., USA:* Kogan Page Limited, 2016, pp. v-viii.

[12] M. Fertsch (ed.), *Elementy inżynierii logistycznej,* Poznan: ILIM, 2016, pp. 11-52.

[13] K. Werner-Lewandowska, M. Kosacka-Olejnik. „Logistics maturity model for service company – theoretical background,” presented at the 28th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM2018), Columbus, OH, USA, 2018.

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