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The maturity model of logistic centres

Model dojrzałości centrów logistycznych

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Abstract. Objectives: The main aim of the article is to present the authors' model of the maturity of logistic centres, in its original, previously published version and improved for the purpose of testing the reliability of logistic centre characters. The second purpose of the article is to justify the possibility of using the maturity model to ensure the reliability of logistic centres. Methods: To carry out the research and prepare the article, an expert (Delphic) method was used, using the knowledge of experts professionally connected with logistic centres, and a literature review. Results: The conclusion of the research and analysis of the results is an improved model of logistic centre maturity compared to previous work. Conclusion: The developed model of logistic centre maturity allows for a comprehensive analysis of the logistic centre's maturity, locating points in need of improvement, and allows continuity and reliability of the centre's operation to be ensured. Highlights:

- The reliability of logistic centres is extremely important for supply chains;
- The maturity model of logistic centres allows for a comprehensive analysis of the examined centre;
- Maturity models are an accepted method of ensuring business reliability;
- The maturity model developed helps to ensure the reliability of the centres.

Keywords: logistic centre, logistic, maturity model, reliability, efficiency

Abstrakt. Cele: głównym celem artykułu było zaprezentowanie autorskiego modelu dojrzałości centrów logistycznych, w jego pierwotnej, wcześniej publikowanej wersji oraz udoskonalonej na potrzeby badania niezawodności centrów logistycznych postaci. Drugim celem artykułu było uzasadnienie możliwości wykorzystania modelu dojrzałości w celu zapewnienia niezawodności funkcjonowania centrów logistycznych.

Metody: do przeprowadzenia badań i przygotowania artykułu zastosowano metodę ekspercką (delficką), wykorzystując wiedzę ekspertów związanych zawodowo z centrami logistycznymi, oraz przegląd literaturowy. Wyniki: Wynikiem przeprowadzonych badań i analizy wyników jest udoskonalony w stosunku do wcześniejszych prac model dojrzałości centrum logistycznego. Opracowany model posiada pięć poziomów dojrzałości w dwunastu obszarach przedmiotowych i stosowana jest w nim reprezentacja ciągła. Dla spełnienia postulatu skutecznego funkcjonowania centrum logistyczne powinno spełniać co najmniej warunki trzeciego poziomu dojrzałości ocenianych obszarów. Konkluzja: Opracowany model dojrzałości centrum logistycznego może być wykorzystywany do przebadania i określenia poziomu rozwoju centrum w najważniejszych obszarach jego funkcjonowania, równocześnie pozwalając na odpowiednią ocenę skuteczności jego działania poprzez kompleksową analizę dojrzałości centrum logistycznego, zlokalizowanie punktów wymagających usprawnień. Pozwala on zapewnić ciągłość i niezawodność funkcjonowania centrum. Najważniejsze wnioski i efekty: -Niezawodność centrów logistycznych jest niezwykle istotna dla łańcuchów dostaw; -Model dojrzałości centrów logistycznych pozwala na kompleksową analizę badanego centrum; -Modele dojrzałości są przyjętą metodą zapewnienia niezawodności przedsiębiorstw; - Opracowany model dojrzałości wspomaga zapewnianie niezawodności centrów.

Słowa kluczowe: logistyka, efektywność, niezawodność, centrum logistyczne, model dojrzałości

Introduction

The scientific literature, particularly the Polish one, does not generally address the problem of the correctness and effectiveness of logistic centres, usually taking them for granted instead. Simultaneously, it should be noted that the topic of the effectiveness in logistics, both in Polish and foreign works, is discussed widely and in many aspects. Most of these works, however, focus on the effectiveness of the supply chains; an example being the often cited article “A framework for analysing supply chain performance evaluation models” by Estampe D., Lamouri S., Paris J-L. and Brahim-Djelloul S. [11]. In the authors’ opinion, however, it is worth/needed to focus on the lower level; a link of the supply chain, the effectiveness of a logistics centre’s. It is a subject much more rarely touched upon, but crucial, as logistic centres are among the most important facilities of point infrastructure in supply chains and have a significant and far-reaching impact on their functioning. This opinion is confirmed by S. Kauf and A. Laskowska-Rutkowska [29] in their article, stating “they are the main elements of regional and international macrologistics systems, linking streams of goods flowing through global supply chains”. This gap is particularly important because [45] “supply chains are now, as never before, extremely complex and sophisticated in nature, which makes them exceptionally vulnerable to various threats”. The reliability aspect of logistic centres is by far less neglected, both with works studying the logistic centres’ reliability and resilience [58] and with the extensive research on the reliability of the entire supply chain [22]. In the authors’ opinion, however, this topic still needs further research and improvement of the currently used methods of evaluating the reliability of logistic centres in accordance with one of the postulates of a modern approach to reliability: the assumption that reliability and security depend not only on the product or service itself, but also on the company providing it [8]. Because of this, [30] “the logistics maturity of the service enterprises should be assessed, since the intangible

service requires material logistic support, without which it cannot be performed”, in which the service enterprises include the logistic centres. Logistics maturity was defined based on a general definition; as [57] “maturity in management is defined as a measurement of the ability of an organization for continuous improvement in a particular discipline”, logistic maturity will mean the measurement of the organization’s ability for continuous improvement in a field of logistics.

In order to fill the existing research gap, the authors of this paper developed a method for assessing the efficiency of logistic centres, the main part of which is the model of the logistic centres’ maturity. Thus, the main aim of the article is to present the developed model of maturity of logistic centres, its improved form modified for more effective reliability analysis, and to discuss its application to work on the analysis of reliability of logistic centres. An additional, added value for the model developed is the relatively low popularity of research on maturity models in the Polish management science, which additionally contributes to the novelty of the solution. Even in the world scope literature, this topic is relatively rarely touched upon, as the majority of the publications which describe the maturity levels in logistics concentrate on the maturity models of enterprises in various branches [4], [7], [54], warehouses/storages [46], [56] or the supply chain [2], [9], [23], [44], [50] and not particularly on the logistics centre, which is a specific nodule of supply chains. The authors, then, concentrate on a relatively rarely described subject and develop their own, novel model of the logistic centre’s maturity. The developed model is, therefore, a research novelty and the authors’ own input into the reliability and logistics sciences, created in order to support the assessment of the logistic maturity of a supply chain, a very important research region, through developing the maturity model of one of the most important loops of the chain. The maturity models applicable to business are especially important at the current time, as, as stated in Karolina Werner-Lewandowska’s article [57], the research of the logistics maturity are still relatively rare in Poland.

The original version of the maturity model had previously been published in one of the authors’ monograph.

The article consists of the following:

- introduction, in which the research gap and the article’s aim are presented;
- chapter I, which presents the possibilities of using the maturity models for the purpose of ensuring the reliability of an enterprise’s, in this particular case a logistic centre’s, functioning;
- chapter II, which presents the method used and the results of the conducted research;
- chapter III, which presents the model of logistic centre’s maturity, developed in accordance to research results and concentrated on ensuring the centre’s functioning’s reliability;
- summary.

A broad literature review and expert (Delphic) studies were used as research methods for the development of the logistic centre maturity model discussed in the article.

Model of maturity and reliability

The maturity model developed was originally designed to test the efficiency of the logistic centre. It should be noted, however, that in the case of a facility such as a logistic centre, the effectiveness of its operation requires, by definition, reliability. A logistic centre with long-term downtime in its logistics operations does not function properly, let alone effectively.

Reliability is defined as [24] “the ability of an item to perform a required function, under given environmental and operational conditions and for a stated period of time” or similar [10] the “probability that an item will carry out its assigned mission satisfactorily for the stated time period when used under the specified condition”. However, in the case of logistics systems, including supply chains, there is no clear definition of reliability [22], [42]. In the case of business logistics, this refers primarily to ensuring the timely and uninterrupted flow and delivery of products. Reliability can also be considered in the context of the supply chain and defined as the ability of a metalogistics system to meet the needs of the end customer.

Thus, the reliability of the logistics system can be defined as [42] “the ability of the system for undisturbed implementation of the process supporting the technical system in terms of providing the necessary logistical resources (...), within a specified period of time and established operational conditions.”, or in a similar perspective [33] “as the ability of the metalogistics system to meet the needs of the end customer”. X. Jia, L. Cui and L. Xing postulate in their article [22] “the adoption of the definition of supply chain reliability is decided by the system model and needs of the system manager”, suggesting a kind of liquidity in the choice of the supply chain reliability definition. Among the examples of their definitions of supply chain reliability for the purposes of the article, the definitions [22] “the probability of the chain meeting mission requirements to provide the required supplies to the critical transfer points within the system” and [22] “the ability to meet the logistic performance expectations of customers” have been adopted and also referred to as logistic centres (as the most suitable). The model of logistic centre maturity developed allows for the analysis and identification of weaknesses in the centre’s development that could negatively affect its ability to smoothly implement logistic processes, allowing for the expansion and improvement of the centre’s operations in aspects that are unreliable or ineffective at the current stage of development. Thus, according to all the analysed definitions – both general reliability definitions and

the three analysed definitions related to logistics reliability – the application of the developed maturity model contributes to the reliability of the centre's operation.

It should be noted here that the use of maturity models for reliability testing is not a new concept either in science or business – examples of its use include theoretical papers [8], the use of the model [3] to evaluate companies from the electronics industry, or the existing and used in business Reliability Life Cycle Maturity Model (RLCMM) [1]. “Maturity models are non-restrictive and can be developed for any process or organisational space that requires improvement. They have been applied to innovation, business process, new product development, project management, supply chain management, and people capability, among others.” The maturity models are commonly used in logistics, especially in the analysis of the supply chains [2], [9], [23], [44], [50].

Results of research conducted

The study was preceded by a literature review and expert consultation to prepare a research questionnaire, which utilised expert (Delphic) studies as research methods. During the research, the work of leading Polish and foreign researchers dealing with logistic centres was used – especially I. Fechner [12-14], J. Fijałkowski [16], S. Bartosiewicz [18], E. Gołemska [19], I. Meidutė [36], S. Markusik [35], J. Miklińska [37], L. Mindur [38], M. Mindur [39], B. Skowron-Grabowska [47,49], and C. Thies [55]. In addition to the preparation of the questionnaire, the main objective of the review was to develop an original definition of logistic centres [26], in order to facilitate the proper selection of research facilities, including the elimination of facilities commonly referred to as logistic centres, but which do not actually meet their requirements – primarily distribution centres [27]. This is particularly important because of the large number of facilities wrongly referred to as logistic centres in Poland [20]. Due to the variety of concepts of the logistic centre in Europe, differing in scope and operational capabilities [40], it should be noted that the definition developed and applied to the selection of research facilities is a general definition, however, adapted primarily to Polish conditions.

After receiving positive opinions from the experts consulted on the planned expert (Delphic) research questionnaire, its form was finalised and the research was started. The questionnaire contained five main factors examined: the cost of services offered, the range of logistics services offered, the quality of logistics services provided, the technical solutions used, and the location of the logistic centre. Each of the above factors contained five lower-order elements – a total of 25 lower-order factors. Managers and employees in senior logistics positions in the logistic centres, as well as independent experts cooperating with them, have been selected as experts. The results of the study are presented in the tables below.

Table 1. Factors that have a decisive influence on the functioning of a logistic centre (Level II objectives)

Target name		Mean	Standard deviation	Coefficient of variation
C1	Cost of the services offered	32.1	3.83	0.12
C2	Range of logistics services offered	15.6	2.54	0.16
C3	Quality of services provided	20.1	4.84	0.24
C4	Technical solutions applied	9.7	1.21	0.12
C5	Location of the logistic centre	22.6	5.17	0.23
Concordance ratio		0.717		
Criterion χ^2		48.788		
Table value χ^2		9.49		

Source: Own study

After multiplying the mean values (which are at the same time the value of the local priority) of the relevant Level II and Level III objectives, the system priority of Level III objectives was obtained, which will be the target weighting of a given factor for the functioning of the logistic centre.

Table 2. Systemic priorities of the factors that have a decisive influence on the functioning of a logistic centre

Systemic priorities of the factors that have a decisive influence on the functioning of a logistic centre		
Target name		System priority value [%]
C1 Cost of the services offered		
C11	Cost of warehouse space rental	14.57
C12	Maintenance fee	5.70
C13	Media costs (heating, electricity, water)	5.37
C14	Rent-free period	3.69
C15	Cost of additional services (e.g. security)	2.74
C2 Range of logistics services offered		
C21	Available storage space	4.26
C22	Possibility of comprehensive logistics service	4.28
C23	Having its own transport fleet	2.31
C24	Possibility of organising forwarding through the centre	2.49
C25	Operator's consultancy on logistics solutions in the centre	2.25

Tab. 2. *cd.*

Systemic priorities of the factors that have a decisive influence on the functioning of a logistic centre		
C3 Quality of service provided		
C31	Flexibility of operation	3.93
C32	Timely service	6.10
C33	Average level of damage to stored goods	3.19
C34	Customer service level	4.13
C35	Availability of additional services	2.73
C4 Technical solutions applied		
C41	High-bay warehouse	3.31
C42	Automation of the storage process	1.63
C43	Presence of an intermodal transport terminal	1.73
C44	Quality assurance systems in place	1.55
C45	Safety systems used	1.48
C5 Location of the logistic centre		
C51	Availability of human resources	4.16
C52	Degree of connection with the international transport system	5.16
C53	Proximity to large urban centres	4.68
C54	Quality of road and telecommunications infrastructure	6.46
C55	Relations with public institutions	2.09

Source: Own study

By comparing the above results in the table according to the limits of the ranges, the following distribution of importance of the factors was obtained:

Table 3. Distribution of factors in ranges

Distribution of factors in ranges				
No. of the range	Boundaries of ranges [%]	Determination of factors	„Specific gravity” of the range (%)	Average value of the system priority of the factor in the range (%)
1	11.49-14.80	C11	14.77	14.77
2	8.17-11.48	-	0	0
3	4.85-8.16	C12, C13, C32, C52, C53, C54	34.54	5.76

cd. tab. 2

Distribution of factors in ranges				
4	1.53-4.84	C14, C15, C21, C22, C23, C24, C25, C31, C33, C34, C35, C41, C42, C43, C44, C45, C51, C55	50.85	2.82

Source: Own elaboration

Therefore, according to the experts, the most important factors influencing the functioning of the logistic centre should be:

C11 - Cost of leasing warehouse space: 14.77

C12 - Maintenance fee: 5.99

C13 - Media costs (heating, electricity, water): 5.12

C32 - Timely service: 5.63

C52 - Degree of connection to the international transport system: 5.53

C53 - Proximity to large urban centres: 5.20

C54 - Quality of road and telecommunications infrastructure: 7.06

Based on the analysis of the research results, it was found that, according to the majority of experts, the effectiveness of the logistic centre's functioning is most strongly influenced by the costs of the services offered, including, first of all, the costs of renting warehouse space and the appropriately selected location of the logistic centre.

The operating costs in this case will be largely due to the proper organisation and proper operation of the centre, which will allow for the reduction of its own costs, which in turn will allow for a reduction in the prices offered to customers. This requirement was the most important point taken into account when developing the logistic centre's maturity model. The experts' choice of costs as the most important factor is not surprising, as the high importance of costs for a company's operations is emphasised both in management theory and practice.

The quality and scope of the logistics services offered by the centre were of lesser, although still of importance to experts. From this, we can conclude that according to most experts these elements are not important in themselves. Rather, they add value to other elements. Thus, during further analysis, they were mainly taken into account as elements which allow for a reduction of the centre's operating costs, not as decisive elements. However, they have not been overlooked because, although they are not an element determining the efficiency of the logistic centre, too low a level (in particular the quality of service) may lead to the loss of customers.

According to the experts, the technical solutions applied in the centre are the least important for the functioning of the logistic centre. This is an interesting fact,

especially considering the opinion of many researchers concerning the importance of a reloading terminal for logistic centres. This means that, according to most experts, technical elements of advanced logistics, such as a high-bay warehouse or an intermodal terminal, are more added value than an important element determining the proper functioning of a logistic centre. During the development of the maturity model, these elements were therefore considered to be the final stages of the centre's development, not necessary for its proper functioning and rather the crowning achievement of the highest stages of its development.

The great importance of the location of the logistic centre emphasises the importance of using appropriate methods to determine the profitability of its location at the investment planning stage. It constitutes a confirmation of the correctness of the development of these methods in the world science of logistics. In this case, experts have a clear interest in the location of the centre close to significant flows of goods, which may be linked to international transport (e.g. transport corridors) or to the proximity of large urban centres that also offer significant flows of goods around the centre. The experts considered the high quality of road and telecommunications infrastructure to be even more important than the location of the centre in the vicinity of significant flows of goods, which is not surprising – high quality infrastructure in the vicinity of the centre is required for its proper functioning with significant transport flows. As in the case of costs, the high rating of these factors is not surprising when compared to the weight given to these criteria by the scientific community – the choice of the centre's location is a fundamental aspect when deciding on its establishment, and the ways of assessing the potential location have been carefully studied. During the development of the original version of the model, it took into account the significant importance of the location of the centre for the correctness of its functioning; however, in the modified version proposed in this paper, it was abandoned, as the model proposed in this article is meant to support reliability during the centre's existence, and its location is not something that can be influenced after its location.

Logistic centre maturity model

The model of logistic centre maturity developed on the basis of the research results is presented in Table 4 below. It was based in its structure on the MZP (Productivity Management Model) models by A. Kosieradzka [31], as well as on the CMMI (Capability Maturity Model Integration) model, analysed on the basis of the works of T. Kasse [28] and P. Taticchi [53]. The model developed has five levels of maturity in twelve subject areas and uses continuous representation [32]. An earlier version of the maturity model was published in one of the author's monograph, while this article includes its modified version, more adapted to the analysis of the

logistic centre in terms of ensuring operational reliability. The new version of the model includes two additional areas – “The implementation of business continuity management systems” and “The information security system level applied”. The developed model is the authors’ own input into reliability and logistics sciences. Because of model length, Table 4 containing model was moved to Appendix.

The model developed is a universal one, meaning it can be utilised in any logistic centre, possibly with the requirement of small adjustments to better suit a specific logistic centre. The model does not limit the kinds of logistic centres it can be applied to, but it cannot be used to analyse distribution centres. In order to meet the requirement of effective functioning, the logistic centre should meet at least the conditions of the third level of maturity of the assessed areas. The introduction of the fourth and fifth levels of maturity at the centre is not necessarily required, but they are a crowning achievement and optimisation of its functioning.

Conclusion

The paper presents expert research carried out and its results, and includes a model of the logistic centre’s maturity developed on this basis. The model developed has five levels of maturity in twelve areas. The developed model of logistic centre maturity can be used to dismantle and determine the level of development of the centre in the most important areas of its operation, while allowing for a proper assessment of its effectiveness. In the case of a logistic centre, the effectiveness of its operation is inextricably linked to its operational reliability.

Thus, the presented maturity model is at the same time an advanced tool for studying and increasing the reliability of the logistics centre it will be used for the analysis of. Enabling the option of analysing the logistic centre is especially important at the present time, due to the logistic centres’ high impact on the supply chains’ functioning and to the relatively lacking analyses of the Polish service sector’s logistic maturity [57].

The further research of the developed model should concentrate primarily on developing a set of good practices, which will be an element of the logistics centre’s maturity model. Developing those, however, is a work far beyond the scope of the presented article. Another option of development is enriching the maturity level through the employment of multicriteria analysis methods, similarly to the method of evaluation of logistic centres’ functioning, which was one of the authors’ previous work.

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