Systems Logistyczne Wojsk nr 42/2015

SELECTED ASPECTS OF MODELLING ESTIMATING RISK IN PROVIDING LOGISTICS SERVICES

WYBRANE ASPEKTY MODELOWANIA SZACOWANIA RYZYKA REALIZACJI USŁUG LOGISTYCZNYCH

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Abstract: *The paper presents the issues of the neural modelling, used in estimating the risk of providing logistic services. The method presented is a tool to support decision making. Its exemplification is shown on the selected example.*
Streszczenie: *W artykule omówiono zagadnienia neuronowego modelowania, wykorzystywanego podczas szacowania ryzyka realizacji usług logistycznych. Przedstawiona metoda jest narzędziem wspomagającym podejmowanie decyzji. Jej egzemplifikację przedstawiono na wybranym przykładzie.*
Keywords: *risk, artificial neural networks, logistic services.*
Słowa kluczowe: *ryzyko, sztuczne sieci neuronowe, usługi logistyczne.*

Introduction

Providing logistic services is associated with the risk in those areas that require decision making under (Buła, 2003; Heilpen 2001; Kaczmarek, 2005; Sienkiewicz, 2007; Szkoda and Świderski, 2005):

- certainty – when the threats effects are known,
- uncertainty – when the likelihood of the threats consequences occurring is not known or these effects are difficult to determine,
- risk – when the probability of the threats consequences occurring is known.

The results of the research show [Olkiewicz, 2005] that under conditions of uncertainty the decisions may be made based on the individual approach to the problem, the experience of the past and the memory of the individual events, and not based on the theories of economics.

The risk evaluation is associated with the ability to predict the consequences of events and mathematical calculations of probability. However, in the case of uncertainty, the scope of future adverse events is not known, so it is not possible to estimate the probability of their occurrence (Kaczmarek, 2003).

As a result of the decisions made in the process of providing logistic services, it is necessary to determine the appropriate strategy (Chong and Brown, 2001):

- general strategy – which determines the objectives, resources and methods of risk studying together with planning activities in relation to the risky situations,
- detailed strategy – for specific situations and risk types. This group includes:
  - expansive strategies – implementing high-risk contracts in order to obtain greater benefits than before,
  - conservative strategies – cautiously taking risk estimated at an acceptable level,
  - impansive strategies – avoiding implementation of high-risk contracts.

In order to uniformly approach the risk, this term can be defined as the potential inability to achieve the objectives of the logistic undertaking in question in accordance with the established requirements. These requirements mainly concern: parameters and characteristics of logistic services, its implementation plan, delivery schedule and costs, staff competencies, technologies used (Fig. 1).

In the implementation of logistic processes, it is important not only to skilfully identify the areas and aspects, where we have to deal with the risk and assess its size, but also to answer the question of whether the risk is acceptable for providing a specific service. It is also important to skilfully manage this risk throughout the cycle of implementing logistic process and evaluate it properly in order to make the right decisions. To manage, means: to identify, evaluate its size (value), reduced to an acceptable level (if needed) and take into account the risks identified and evaluated in future similar projects.

The following considerations focus on the issue of risk in the following areas of logistic services: planning, implementation and purchases.

Following the receipt of customer inquiry or order for the logistic service, one makes a risk evaluation in terms of the implementation capabilities. The results form the basis for further, more detailed assessment in the process of: planning, implementation and purchases. This is the basis for the decision to proceed with the order. The correctness of the assessment is verified during and after the completion of service and provides a database for subsequent analysis.

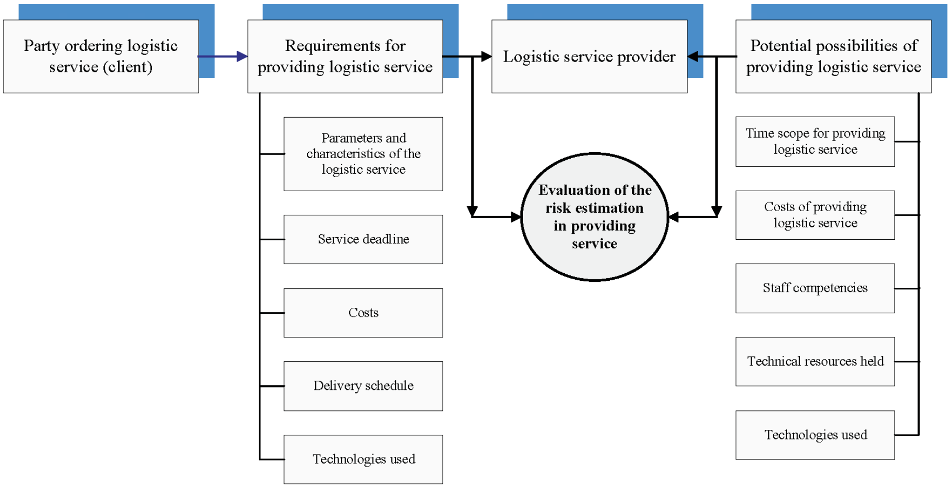

Fig. 1. Evaluation of risk estimation in the process of delivering logistic services
Source: own compilation

In the processes of planning, implementation and procurement of logistic se-rvices, the risk can be seen in the following basic aspects (Świderski, 2011):

- geographic – the ability to deliver the load (persons) to a specific location (j = 1),
- punctuality – the ability to deliver the load (persons) within a specified time (j = 2),
- technical – the ability to deliver the load (persons) using the required trans-port means (j = 3),
- quality – the ability to deliver the load, ensuring its correct (as required by the customer purchasing transport service) quality (j = 4),
- cost – the ability to deliver the load (persons) at a fixed cost (j = 5).

The risk value in the individual aspects can be calculated using the formula (Świderski, 2011):

$$R_j^k = s_j^k \cdot p_j^k \tag{1}$$

where:

R_j^k – value of the risk in *k*-th area and in *j*-th aspect,

s_j^k – value of the threat's consequence in the *k*-th carea and in *j*-th aspect,

p_j^k – probability value of the threat occurrence in the *k*-th area and in the *j*-th aspect.

Risk management can be divided into activities involving the risk evaluation and its control (Kaczmarek, 2003). Risk evaluation includes risk identification and risk analysis. Risk control consists of risk reduction and monitoring. Risk identification involves identifying areas of risks occurrance, aspects, causes, correlations between individual aspects. Risk analysis involves performing risk classification based on the value of the product of the threat consequence and the probability of its occurrence. It is also necessary to specify the significance and importance of each risk in the context of the possibility to provide logistic services. Following identification and analysis, the reduction and monitoring is carried out. Risk reduction in the processes of providing logistic services comes down to implementing the procedure, taking into account the resources and methods to reduce the risk to an acceptable level. In order to reduce risk one ought to implement actions eliviating the existing hazards, eliminating the causes of these threats and preventing the formation of potential threats in the future. The next step is to monitor risk by:

- evaluating the correctness of the reducing measures undertaken,
- identification and estimating each new emerging type of risk or supervising the importance of partial risk,
- implementation of new measures, if the current ones are considered unreliable.

Risk monitoring relies on observing realizing logistic services processes for proper implementation of measures to reduce the risk. This enables ongoing evaluation and initiating changes, depending on the level of risk.

It is required that the processes of: identification, analysis, monitoring and risk reduction were conducted in all areas of logistic services (planning, implementation and purchases).

1. General aspects of modelling

Evaluation model of estimating risk of logistic services should reflect the complexity and interdependence of the processes identified in the course of their implementation. The model is a representation of reality, and in this case - estimating the risk of providing logistic service, done at a given time. It is regarded as a deliberately simplified representation of the basic features of this reality, relevant to the intended purpose of the research (Jacyna, 2001). During the quality evaluation there is therefore no need to analyze all specific problems. The reality representation in the model depends on many factors, in this case, mainly on the skills and knowledge of evaluators. Due to simplification of the representation of the modeling object, the following models can be distinguished (Jacyna, 2009):

- descriptive, presenting characteristics of the object in a form of description,
- physical, representing activity of the real object (allowing for direct experimental studies) by using physical quantities in a different scale,
- analog, using the possibility to present some properties using the others,
- mathematical, reproducing all relevant phenomena in the modelling object in the form of mathematical and logical relationships.

The deliberations assume that the modeling is the process of choosing a replacement for the original, called a model, replicating a reality tested, and then experimenting with it. It is therefore an experimental and mathematical method to study complex systems, phenomena and processes based on models constructed (Jacyna, 2001). The algorithm to build a model for estimating the risk of providing logistic services is shown in Fig. 2.

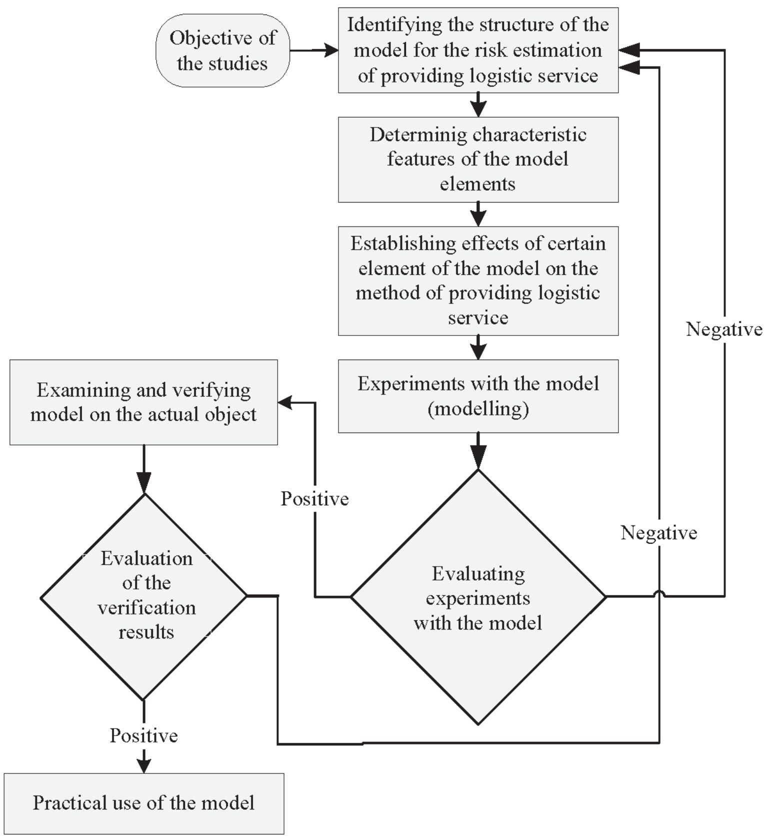

Fig. 2. The algorithm to build a model for evaluating implementation of the logistic services
Source: based on (Jacyna, 2001; Świderski, 2011)

The issues of risk assessment modelling in the implementation of logistics services mainly relate to areas where there are problems of reproducing complex, non-linear relationships between certain inputs and selected outputs. Risk assessment modeling in delivery of the logistic is characterised by the necessity to solve problems that require experts' experience, acquired throughout the years of activity in the widly understood logistics. For this reason, the mathematical modeling can be used taking into account the artificial neural networks for they can easily reproduce the nonlinear dependences.

The mathematical model of risk assessment in the process of providing logistic services, can be represented by the function $\Gamma(t)$, in the form (Świderski, 2011):

$$\Gamma(t) = f\left(\gamma_1(t), \gamma_2(t), ..., \gamma_M(t)\right) \tag{2}$$

where:

$\Gamma(t)$ – risk estimation evaluation at the moment t,

$\gamma_m(t)$ – evaluation at the moment t of the m-th process associated with the risk estimation in providing logistic services, where $m = 1, 2, ...M$.

2. Neural modelling

Neural modeling was carried out using JETNET 2.0 computer program developed in FORTRAN 77 (Lonnblad, Peterson and Rognvaldsson, 1992), that uses the algorithm for the momentary backward error propagation method. Modeling was performed according to the algorithm shown in Fig. 3.

The data to build a network is an expert evaluation, parameterized according to the accepted criteria, of individual risk assessment processes and final risk evaluation before the conclusion of the contract for providing logistic services. This data came from real processes of providing logistic services resulting from contracts signed by the military repair and manufacturing companies. The evaluation was done by the experts of the certification body (Department of Quality and Management Systems, WAT) in the certification processes.

For the purpose of objective judgment of an expert evaluation of the risk estimate of providing logistic service, the risk matrix is used (Table 1). Also the "Charter of the risk assessment (Table 2) was used.

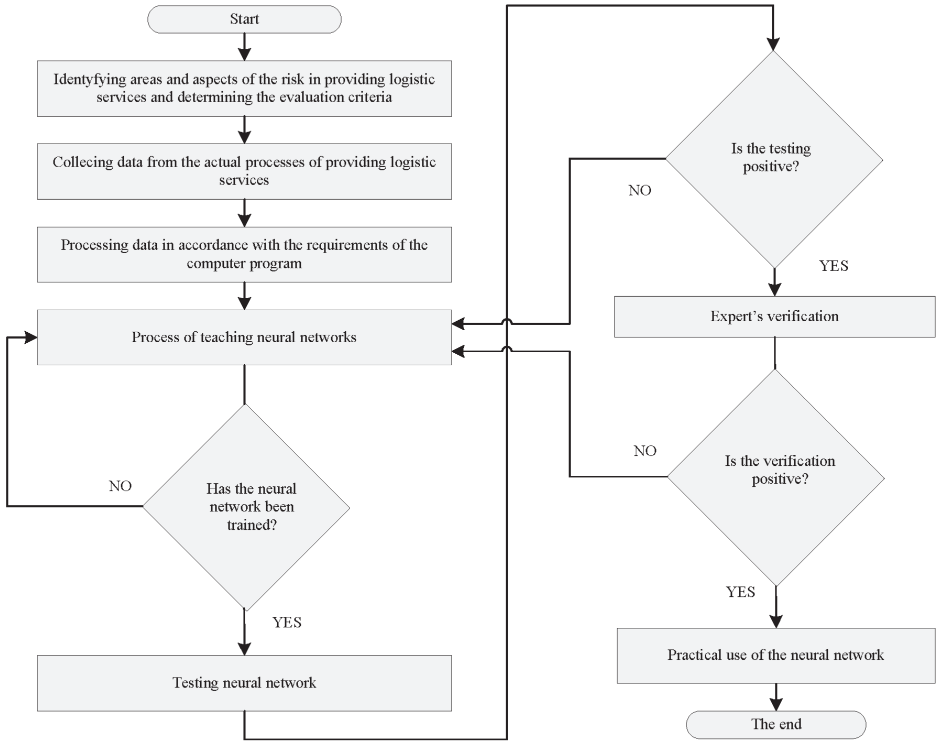

Fig. 3. Algorithm for building a model to estimate the risk of providing logistic services
Source: based on (Świderski, 2013)

Table 1. Risk Matrix

Effect of a threat						
	1	0	0,25	0,5		
	0,75	0	0,187	0,375	0,562	
	0,5	0	0,125	0,25	0,375	0,5
	0,25	0	0,062	0,125	0,187	0,25
	0	0	0	0	0	0
		0	0,25	0,5	0,75	1
	Probability of a threat occurring					

Source: based on (Świderski, 2011)

Table 2. Risk assessment card

Undertaking											
Implementation process	Aspects	**Risk value**									
		0	**0,0625**	0,125	0,187	0,25	0,375	0,5	0,562		
Planning	Geographic										
	Punctual										
	Technical										
	Qualitative										
	Cost										
Implementation	Geographic										
	Punctual										
	Technical										
	Qualitative										
	Cost										
Purchases	Geographic										
	Punctual										
	Technical										
	Qualitative										
	Cost										
TOTAL RISK VALUE OF THE UNDERTAKING											

Source: based on (Świderski, 2011)

The value level of 0.75-1 represents high risk, which in practice translates into a high probability of a threat occurring or significant threat impact. Moderate risk of the value between 0.375-0.562 involves substantial likelihood of the threat occurring and moderate consequences of its impact. The low risk level (0-0.25) is in the case of a small probability of the threat occurring and negligible effect of its impact.

The studies used multi-layer perceptron (linear network, one-way and multi-layered) with 1 output neuron and 15 input neurons. Neural networks with different structures were examined (different learning coefficients η, momentum, iteration numbers, numbers of hidden layers and numbers of neurons contained in them).

Sample results are included in Table 3. The accuracy of the neural network learning was measured with a learning error $\chi^2_{śr}$ and % of positive events.

Table 3. Sample studies results

No.	α	η	N	Number of neurons in the hidden layers:				% of positive events	$\chi^2_{śr} 10^2$
				1.	2.	3.	4.		
1	0,5	0,05	10^7	15	10	5	3	100	0,0003
2	0,5	0,05	10^7	10	10	5	-	100	0,0011
3	0,5	0,05	10^7	15	8	-	-	100	0,0002
4	0,5	0,05	10^7	10	10	-	-	100	0,0004
5	0,5	0,05	10^7	10	-	-	-	100	0,0004
6	0,5	0,10	10^6	15	10	5	3	93,16	0,36
7	0,8	0,05	10^6	15	10	5	3	99,66	0,030
8	0,5	0,10	10^6	15	10	5	-	100	0,008
9	0,5	0,05	10^6	15	10	5	-	100	0,011
10	0,8	0,05	10^6	15	10	5	-	100	0,006
11	0,5	0,10	10^6	15	8	-	-	100	0,006
12	0,5	0,05	10^6	15	8	-	-	99,66	0,019
13	0,6	0,05	10^6	15	8	-	-	100	0,013
14	0,8	0,05	10^6	10	-	-	-	100	0,008
15	0,5	0,05	10^5	10	10	-	-	96,78	0,15
16	0,5	0,05	10^5	10	10	5	-	89,92	0,40
17	0,5	0,05	10^5	15	8	-	-	96,78	0,17

Source: based on (Świderski, 2011)

Trained neural networks have been tested. The essence of network testing came down to determining the value of input and output signals, which have not been used to build the model. To test the network therefore, the data from 20% of other contracts has been used (in relation to the number of contracts to be taken into account in the teaching the network).

Table 4 shows examples of the results of testing of selected artificial neural networks.

Table 4. Examples of tests results

No. of network from the Tab. 2	% of positive events from teaching the network	$\chi^2_{śr} 10^2$ from teaching the network	% of positive events from teaching the network	$\chi^2_{śr} 10^2$ from teaching the network
1	100	0,0003	100	0,0003
2	100	0,0011	100	0,0010
3	100	0,0002	100	0,0002
4	100	0,0004	100	0,0004
5	100	0,0004	100	0,0003

No. of network from the Tab. 2	% of positive events from teaching the network	$\chi^2_{śr} 10^2$ from teaching the network	% of positive events from teaching the network	$\chi^2_{śr} 10^2$ from teaching the network
10	100	0,006	100	0,006
11	100	0,006	100	0,006

Source: based on (Świderski, 2011)

Summary

The risk management in the processes of providing logistic services requires continuous data collection, improving risk assessment principles and controling it in all areas and aspects. Effective risk management should lead to a reduction in its value to an acceptable level, thereby to optimizing costs. Using artificial neural networks helps to support making the right decisions. This topic may inspire continuing the work, which could greatly contribute to the expanding risk management methods of the theory and practice using artificial neural networks.

The neural model verification, carried out, of the risk estimating assessment in providing logistic services confirmed that:

- the use of the adopted model for the risk estimating assessment in providing logistic services guarantees a consistent and repeatable results of the assessment,
- the use of artificial neural networks provides a solution to the problems of non-linearity and the various aspects of risk estimating in providing logistic services,
- despite the fact that the user needs basic knowledge concerning the choice of the type of network and the process of data preparation in order to create it and be able to interpret the results, it may be concluded that artificial neural networks are convenient, credible and objective tool in the estimation of risk when providing logistics services,
- artificial neural networks may be used as a tool verifying the results of the work of the experts in risk assessment,
- artificial neural networks can support decision-making process related to risk management in logistics.

The results obtained, associated with the use of neural networks in the estimation of risk, justify the statement that a mathematical model to estimate the risk assessment in the logistic processes, based on multi-layered artificial neural network (multilayered perceptrone), replicates the actual assessment. Such developed model serves a practical support to decision-making concerning the feasibility of the contracts.

LITERATURE

[1] Buła P. (2003), *Zarządzanie ryzykiem w jednostkach gospodarczych. Aspekt uniwersalistyczny*, Wydawnictwo Akademii Ekonomicznej w Krakowie, Kraków.

[2] Chong Y.Y., Brown E.M. (2001), *Zarządzanie ryzykiem projektu*, Dom Wydawniczy ABC, Kraków.

[3] Heilpen S. (2001), *Podejmowanie decyzji w warunkach ryzyka i niepewności*, Wydawnictwo Akademii Ekonomicznej we Wrocławiu, Wrocław.

[4] Jacyna M. (2001), *Modelowanie wielokryterialne w zastosowaniu do oceny systemów transportowych*, Politechnika Warszawska – Prace Naukowe – Transport, z. 47, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

[5] Jacyna M. (2009), *Modelowanie i ocena systemów transportow*ych, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

[6] Jasińska J., Świderski A. (2008), *Metodyka oceny ryzyka w zapewnieniu jakości systemów logistycznych*, Politechnika Warszawska, s. 59-66, Prace Naukowe – Transport, z. 64, Warszawa.

[7] Kaczmarek T. (2005), *Ryzyko i zarządzanie ryzykiem. Ujęcie interdyscyplinarne*, Wydawnictwo Difin, Warszawa.

[8] Kaczmarek T. (2003), *Zarządzanie zdywersyfikowanym ryzykiem w świetle badań interdyscyplinarnych. Typologia i semantyka*, Wydawnictwo Wyższej Szkoły Zarządzania i Marketingu w Warszawie, Warszawa.

[9] Lonnblad L., Peterson C., Rognvaldsson T. (1992), *Pattern recognition in high energy physics with artificial neural networks – JETNET 2.0*, s. 167-182, Computer Physics Communications, vol. 70.

[10] Olkiewicz A. (2005), *Ograniczanie niepewności i ryzyka w działalności handlowej firmy*, Wydawnictwo Poltext, Warszawa.

[11] Nałęcz M. (2000), *Biocybernetyka i inżynieria biomedyczna. Sieci neuronowe*, Akademicka Oficyna Wydawnicza EXIT, z. 6, Warszawa.

[12] Rutkowski L. (2005), *Metody i techniki sztucznej inteligencji*, Wydawnictwo Naukowe PWN, Warszawa.

[13] Sienkiewicz P. (2007), *Teoretyczne podstawy zarządzania ryzykiem*, Zeszyty Naukowe Akademii Obrony Narodowej, z. 2, Warszawa.

[14] Szkoda J., Świderski A. (2005), *Problemy oceny skuteczności jakościowej procesów realizacji wyrobów w aspekcie wymagań AQAP*, Wydawnictwo Europejskiego Instytutu Jakości, Warszawa.

[15] Świderski A. (2011), *Modelowanie oceny jakości usług transportowych*, Politechnika Warszawska – Prace Naukowe – Transport, z. 81, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

[16] Świderski A. (2013), *Modelowanie neuronowe w zastosowaniu do oceny jakości w logistyce*, Gospodarka Materiałowa & Logistyka, nr 5/2013, Warszawa, s. 619-629.