EXPERIMENTAL EVALUATION OF COMPETITIVENESS OF LOGISTICS EQUIPMENT

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Abstract. This study presents an examination of an experimental evaluation of the competitiveness of a typical representative of logistics equipment – forklifts with internal combustion engines (ICE forklifts), including assessing the competitiveness of a particular brand of forklifts, applying the emotional method.

Keywords: competitiveness, experimental evaluation, logistics equipment, forklift, emotional method

1. Introduction

Globalization and global markets require more complete satisfaction of customer requirements. This leads to increased competition and search for new ways to successful market presence. This is very important for small and medium-sized enterprises producing logistics equipment, which to survive must actively co-operate. This cooperation was formalized in innovation, i.e. joint development and production of competitive models. The application of the approach "Clever Rational Society" (CRS) [1], is needed providing the best way for cooperation via the Internet. Thus experts from the cooperating countries may design and carry out the assessments, including experimental, to new innovative developments.

The competitiveness of a company can be achieved by applying the ideas of the model of Nonaka & Takeuchi for creating knowledge [2]. The experimental evaluation completes the explicit knowledge in the model and creates a favorable environment for interaction between the hidden and obvious knowledge so necessary for implementation of daily business activities.

It is known [3] that competitiveness may be specific and general. Specific competitiveness is defined regarding a particular model of a particular company.

Evaluation of innovative alternatives is of great importance in making sound management decisions for the selection of variants of process innovations. It promotes the targeting of investments and achieving higher company competitiveness. Without its implementation it is not possible to properly plan innovative activities and maximizing business results remains an abstract thinking. The assessment is used to determine the expected impact of any possible process innovation on the economic performance of the enterprise, to make comparisons with other alternative innovations and innovations of other enterprises. On its basis the strengths and weaknesses of innovative options are analyzed, which will lead to improved outcomes, and hence the competitive position of the company. Supporting the analysis of various alternatives for management decisions, it is also a condition for the development and selection of strategies for development [4].

The meaning of the assessment is to carry out comparisons with other innovations and making choice of innovative option in which to invest.

The proposed methodology is based on the methodology for determining the competitiveness of the business, shown by Velev, M. [5].

The purpose of this work is to show an experimental assessment of the competitiveness of a typical representative of logistics equipment – ICE forklifts, including assessing the competitiveness of a particular brand of forklifts (Toyota), applying The emotional method using *HTML, XML, VML, VB Script and Java Script* based experimental *Web* application.

The technical competitiveness [6], as part of the overall competitiveness of the trucks will be examined. This work will be based on [7, 8] which offer methods for determining the parameters of the forklift trucks.

In order to achieve competitiveness at the time of implementation of logistic machine (not at the time of bidding) the development [9] will be taken in account.

Because of the fundamental importance of ergonomics in the development of modern trucks, an important quality is the ability of the proposed methodology to take into account when examining the requirements of [10].

The paper reviews the production of the companies Nissan, Jungheinrich, Komatsu, Linde, Mitsubishi, Toyota, Hyundai, Artison, Cesab, Clark, Doosan, OMG, Tailift, Yale, Cheuklift, Goodsense, GP, Maximal, Nissan, Shangli, UN [11, 12, 13, 14].

2. Restrictions regarding parameters

At any one time point [6] t_i there is a minimal $O_{i,\,min}$ and maximum $O_{i,\,max}$ limit of the value of the parameter P_i (i = 1, 2, ..., n), through which an assessment of its quality can be made. The upper limit of the restriction is set by the minimum value of the upper limit of the two restrictions:

$$O_i^{max} = \min\left\{O_{bi}^{max}, O_{Ti}^{max}\right\} \quad (i = 1, 2, \cdots, n). \qquad (1)$$

The lower limit of the restriction is set by the larger value of the lower limits of two restrictions:

$$O_i^{min} = \max\left\{O_{bi}^{min}, O_{Ti}^{min}\right\} \quad (i = 1, 2, \cdots, n). \qquad (2)$$

Since the experimental calculation of technical competitiveness of logistics equipment is based on already designed and manufactured machines, it is assumed that the values of all their parameters are within the limits set by the restrictions. In this regard, the maximum and minimum values of the spread-area of the values of the parameters will be determined by the maximum and minimum values of these parameters or:

$$O_i^{max} = P_i^{max} \qquad (3)$$

and

$$O_i^{min} = P_i^{min}, \qquad (4)$$

where

$$P_i^{min} \leq P_i \leq P_i^{max}. \qquad (5)$$

3. Determination of basic parameters used for a base for competitiveness assessment

In the present model the technical competitiveness of the machines is considered as a function of different characteristics, where each characteristic itself is regarded as a function of different parameters. The degree of influence of each parameter is set by the assessor as:

$$0 \leq K_i^{\frac{п}{х}} \leq 1 \quad \text{and} \quad \sum K_i^{\frac{п}{х}} = 1$$

3.1. ICE Forklifts

For the purpose of this study these quality characteristics and parameters are considered as functionally determining:

Quality of construction
Dynamics and manoeuvrability
Economy
Reliability
Quality of design.

These features are selected by specifying the technical competitiveness of the products during the entire life cycle - from design to post-exploitation. (Table 1).

Out of values available in the database of machines for each parameter the maximum value, the minimum value and average annual value for each year of the scanned period are defined, forming the evaluation areas. Area of positive assessment is the area between the line of the overall average and maximum limit of the parameter expressed by the maximum value of the sample. Zone of negative or zero mark is formed below the overall average and limited rights below the minimum value of the sample.

The overall average $\bar{P}$ is also a baseline assessment for the year P_0 or:

$$\bar{P} = P_0$$

In cases where the higher value of the parameter means higher score, assessments are calculated using the following formula:

$$q_i^y = \frac{\bar{P}_i^y - P_0}{P_{max} - P_0} \qquad (6)$$

and

$$\begin{cases} 0 \leq q_i^y \leq 1 \; if \; \bar{P}_i^y > P_0 \\ q_i^y = 0 \; if \; \bar{P}_i^y < P_0 \end{cases}$$

In cases where the lower value of the parameter means a higher score, assessments are calculated using the following formula:

$$q_i^y = \frac{P_0 - \bar{P}_i^y}{P_0 - P_{max}} \qquad (7)$$

and

$$\begin{cases} 0 \leq q_i^y \leq 1 \; if \; \bar{P}_i^y > P_0 \\ q_i^y = 0 \; if \; \bar{P}_i^y < P_0 \end{cases}$$

3.1.1. Mass coefficient

The zones of positive and negative marks for the mass coefficient are shown in Figure 1 and Table 2.

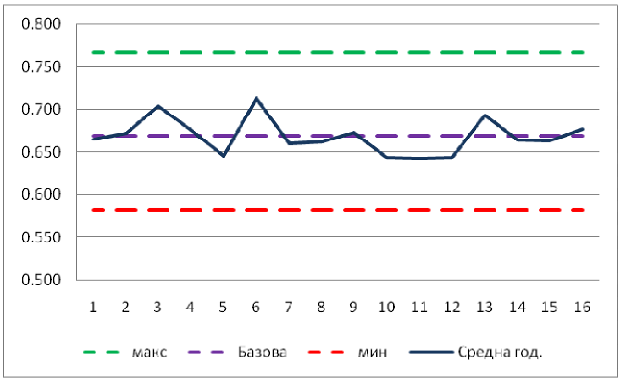


Figure 1. Assessment areas of the mass coefficient of lift trucks

The base value is used to set the relative assessment of the values of the parameters of the tested machines. The values that are greater than the base are set to a positive score in the range {0, 1}, while those values that are lower than the base, are given score 0. These estimates are used to determine the base competitiveness through The Emotional model [11].

Estimates for the mass coefficient of formula (6) are determined and shown in Table 3.

3.1.2. Average travel speed

The zones of positive and negative marks for the average travel speed are shown in Figure 2 and Table 4. Estimates of the average speed in the formula (6) are as shown in Table 5.

Table 1. Parameters and characteristics constituting technical competitiveness of forklifts

Mood	Coef.	Feelings	Coef.	Emotions	Scanned points
					1998-2014
Competitiveness	1	Quality of construction	0.25	Mass ratio	
			0.25	Average speed	
			0.15	Engine power	
			0.2	Warranty period	
			0.15	Dimensions of the machine	
	1	Dynamics and maneuverability	0.2	Mass ratio	
			0.4	Average speed	
			0.2	Engine power	
			0	Warranty period	
			0.2	Dimensions of the machine	
	1	Economy	0.25	Mass ratio	
			0.15	Average speed	
			0.5	Engine power	
			0	Warranty period	
			0.1	Dimensions of the machine	
	1	Reliability	0	Mass ratio	
			0	Average speed	
			0.8	Engine power	
			0.2	Warranty period	
			0	Dimensions of the machine	
	1	Quality of design	0.1	Mass ratio	
			0.2	Average speed	
			0.1	Engine power	
			0	Warranty period	
			0.6	Dimensions of the machine	

Table 2. Statistical assessment data of the parameter mass coefficient

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
$\bar{P}_i^y$	0.665	0.672	0.704	0.676	0.646	0.713	0.66	0.662	0.373	0.644	0.643	0.644	0.693	0.664	0.663	0.677
P_0	0.669															
P_{min}	0.583															
P_{max}	0.767															

Table 3. Assessment values of the parameter mass coefficient

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
	0	0.03	0.36	0.07	0	0.45	0	0	0.04	0	0	0	0.25	0	0	0.09

Table 4. Statistical assessment data of the parameter average travel speed

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	18.98	17.50	18.63	15.05	19.14	17.00	17.03	19.15	17.38	17.95	17.61	18.70	19.25	18.35	18.76	19.00
	18.09															
	12.70															
	22.00															

Table 5. Assessment values of the parameter average travel speed

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
	0.23	0	0.14	0	0.27	0	0	0.27	0	0	0	0.16	0.3	0.07	0.17	0.23

3.1.3. Engine power

For the power of the engine it is considered that the lower power means a higher score, so for the calculation of the assessment formula (7) is applied.

The zones of positive and negative marks for the engine power speed are shown in Figure 3 and Table 6. Estimates obtained through formula (7) are shown in Table 7.

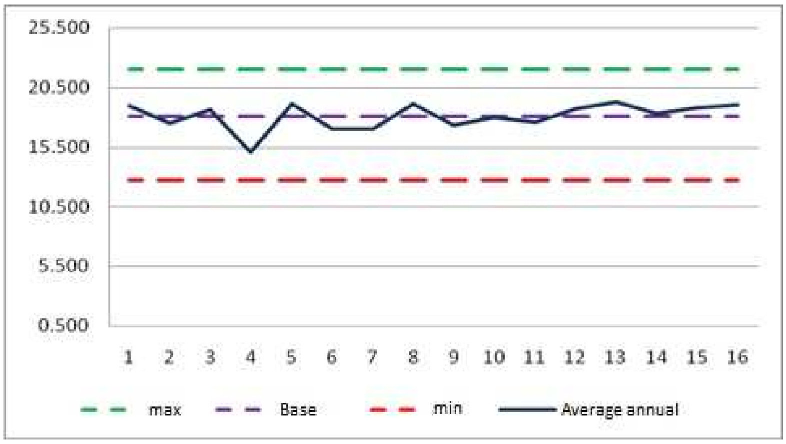


Figure 2. Areas of assessment of the average speed of lift trucks

Table 6. Statistical assessment data of the parameter engine power

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	42.30	39.0	40.8	33.0	40.6	35.0	33.5	41.6	39.0	37.4	37.4	40.8	42.0	37.0	42.2	36.6
	38.63															
	28.0															
	62.5															

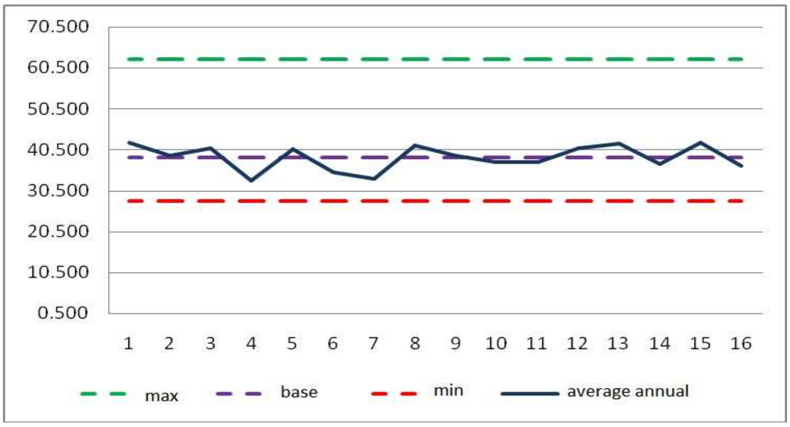


Figure 3. Areas of assessment of engine power lift trucks

Table 7. Assessment values of the parameter engine power

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
	0	0	0	0.53	0	0.34	0.5	0	0	0.12	0.12	0	0	0.15	0	0.19

3.1.4. Gauge volume

For the gauge volume it is considered that a lower value means a higher score, so that the calculation of the assessment is through formula (7).

The zones of positive and negative marks for the engine power speed are shown in Figure 4 and Table 8.

Estimates obtained through formula (7) are shown in Table 9.

3.1.5. Warranty period

The warranty period is a parameter directly influencing the characteristics of after-sales service, and therefore the reliability of the machine. Because its value is a function mainly of the marketing strategy of the company, then its evaluation can't be made by standard procedures. Assessment of the warranty period count is estimated as consisting of two components:

1. Year of manufacturing of the machine
2. Remaining period of the warranty period.

The study of logistics equipment found that the warranty period for the post-maintenance of the machines varies between one and five years.

Table 8. Statistical assessment data of the parameter gauge volume

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	5.95	5.96	6.09	5.29	6.27	5.87	5.87	6.26	5.63	6.02	6.71	6.63	6.30	6.51	6.37	6.15
	6.12															
	4.98															
	7.71															

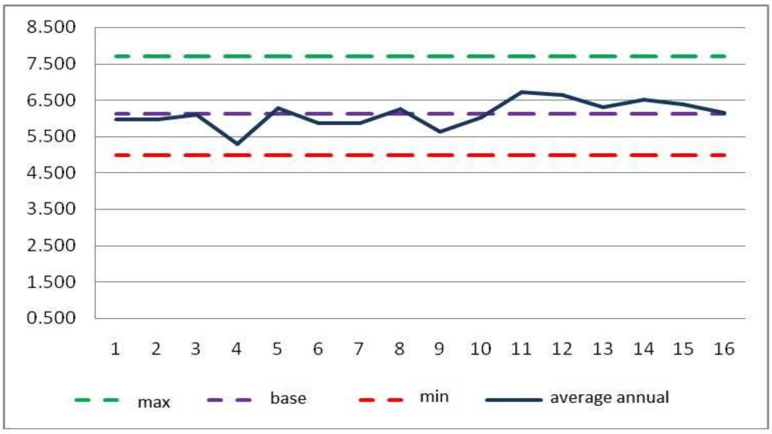


Figure 4. Areas of assessment of the gauge volume of forklifts

Table 9. Assessment values of the parameter gauge volume

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
	0.14	0.14	0.02	0.73	0	0.22	0.22	0	0.43	0.09	0	0	0	0	0	0

Weights are assigned to the appropriate values remaining warranty period as follows:

Remaining time	**5 years**	**4 years**	**3 years**	**2 years**	**1 year**
Weight	1.0	0.8	0.6	0.4	0.2

Weights are assigned for the respective years of production as follows:

Year etc. st	**2013**	**2012**	**2011**	**2010**	**2009**
Weight	1.0	0.8	0.6	0.4	0.2

Multiplying two weights each with each gives a table with the corresponding estimates for each year for each remaining warranty period. The average annual rating gives the assessment for this year, which is used in the emotional model (Table 10).

Table 10. Rating values of the warranty period given by the manufacturer with correlation to the year of production

	Year of production				
Remaining time	**2013**	**2012**	**2011**	**2010**	**2009**
5	1.0				
4	0.8	0.64			
3	0.6	0.48	0.36		
2	0.4	0.32	0.24	0.16	
1	0.2	0.16	0.12	0.08	0.04
Average Rating	**0.6**	**0.4**	**0.24**	**0.12**	**0.04**

3.2. Assessment of estimated values of the parameters

3.2.1. Assessment of quantitative parameters

In order to make recommendations to enhance the technical competitiveness of future models it is needed to set estimates for the forecasted in the previous chapter parameter values. The forecasted values are as follows:

Year	2014	2015	2016
Mass coefficient	0.669	0.669	0.669
Average speed	18.59	18.66	18.73
Engine power	38.14	38.14	38.14
Gauge volume	6.39	6.39	6.39

Applying again equations (6) for the mass coefficient and average speed and (7) for the engine power and gauge volume, the following estimates for the next three years are obtained:

Year	2014	2015	2016
Mass ratio	0	0	0
Average speed	0.13	0.15	0.16
Engine power	0.05	0.05	0.05
-Size volume	0	0	0

3.2.2. Warranty period assessment

For each year, the estimates are transferred one period ahead, but since that time in the future, then for each year there will be assessments of each type, as applicable to assessment in emotional model, we calculate the average score of all possible as follows:

$$(0.6 + 0.4 + 0.24 + 0.12 + 0.04) / 5 = 0.28$$

3.3. Determining the overall base competitiveness using the Emotional model

The developed WEB version of the emotional model [6], based on XML is used as follows.

1. Introducing initial conditions as follows (Figure 5)

- Width-maxX = 550 - sets the maximum width of the chart in px
- Height-maxY = 350 - sets the maximum height of the graph in px
- Number of Emotions (Limited up to 5): - number of tested emotions = 5
- Number of Feelings (Limited up to 5): - number of surveyed feel = 5
- Scanned time points (Limited up to 100): - scanning time points = 19 (for the period 1998 - 2016)
- Discount rate of Feelings (YF between 0 and 1.0): - discount rate = 0.7 feelings default
- Discount rate of Mood (YM between 0 and 1.0): - discount rate = 0.7 mood default

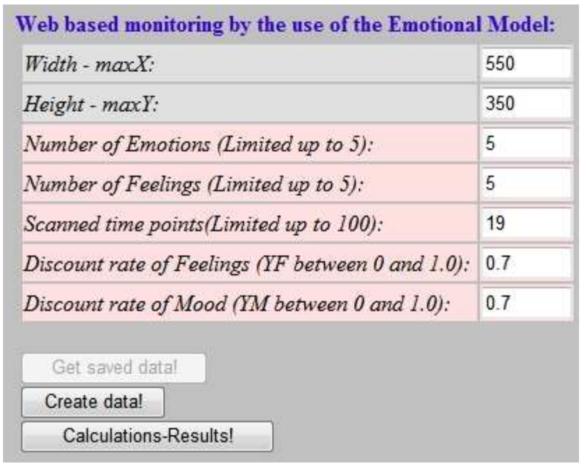


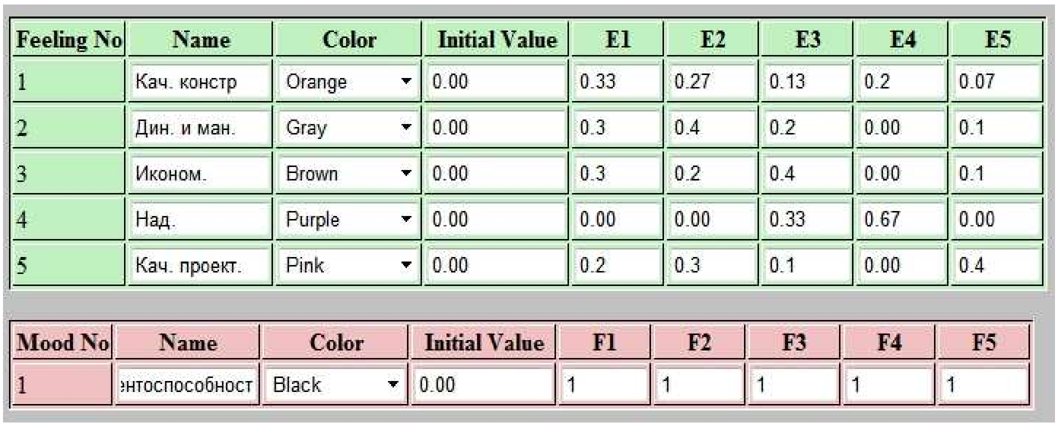
Figure 5. Initial conditions of Web-based software to calculate with emotional model

The parameters are entered in the form of emotions and set the appropriate colour chart (Figure 6)

Emotion No	Name	Color	Initial Value
1	Km	White	0.00
2	Vcp	Red	0.00
3	P	Green	0.00
4	V	Blue	0.00
5	W	Yellow	0.00

Figure 6. Entered parameters in the Web-based software for calculating with The emotional model

2. The characteristics are entered in the form of feelings and define the weighting factor of each parameter to the characteristic (Figure 7)



Feeling No	Name	Color	Initial Value	E1	E2	E3	E4	E5
1	Кач. констр	Orange	0.00	0.33	0.27	0.13	0.2	0.07
2	Дин. и ман.	Gray	0.00	0.3	0.4	0.2	0.00	0.1
3	Иконом.	Brown	0.00	0.3	0.2	0.4	0.00	0.1
4	Над.	Purple	0.00	0.00	0.00	0.33	0.67	0.00
5	Кач. проект.	Pink	0.00	0.2	0.3	0.1	0.00	0.4

Mood No	Name	Color	Initial Value	F1	F2	F3	F4	F5
1	энтоспособност	Black	0.00	1	1	1	1	1

Figure 7. Entered characteristics in Web-based software for calculating with The emotional model

3. The competitiveness is entered in the form of "mood" (Figure 7)

4. The calculated ratings for each scanned point (year) are entered (Figure 8)

Step No	E1 value	E2 value	E3 value	E4 value	E5 value
1	0.00	0.23	0.00	0.14	0.00
2	0.03	0.00	0.00	0.14	0.00
3	0.36	0.14	0.00	0.02	0.00
4	0.07	0.00	0.53	0.73	0.00
5	0.00	0.27	0.00	0.00	0.00
6	0.45	0.00	0.34	0.22	0.00
7	0.00	0.00	0.50	0.22	0.00
8	0.00	0.27	0.00	0.00	0.00
9	0.04	0.00	0.00	0.43	0.00
10	0.00	0.00	0.12	0.09	0.00
11	0.00	0.00	0.12	0.00	0.00
12	0.00	0.16	0.00	0.00	0.04
13	0.25	0.30	0.00	0.00	0.12
14	0.00	0.07	0.15	0.00	0.24
15	0.00	0.17	0.00	0.00	0.4
16	0.09	0.23	0.19	0.00	0.6
17	0.00	0.13	0.05	0.00	0.28
18	0.00	0.15	0.05	0.00	0.28
19	0.00	0.16	0.05	0.00	0.28

Figure 8. Entered assessments in web-based software for calculating with The emotional model

5. The software calculates and displays the results graphically of the change during the years of the assessed as a function of the set parameters and characteristics (Figure 9)

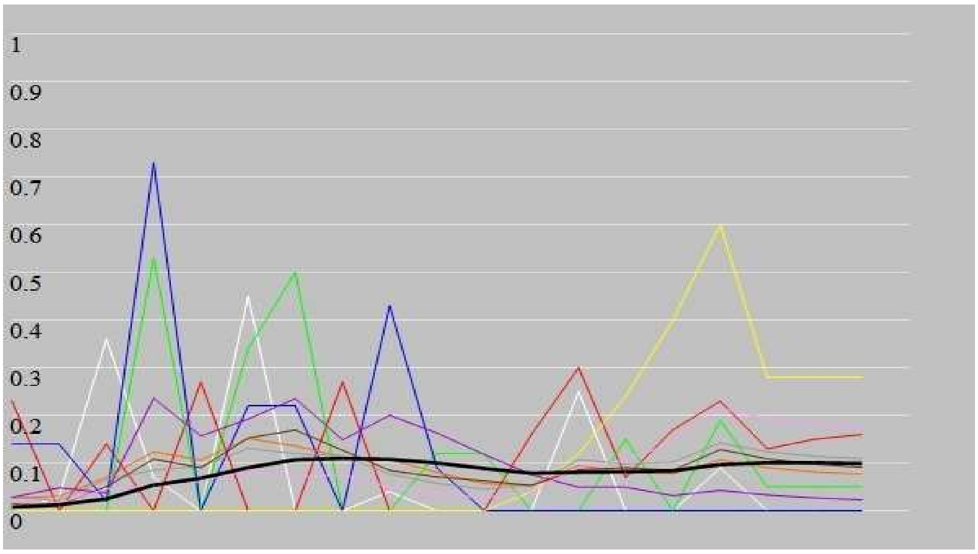


Figure 9. Graph of the change of parameters and characteristics over the years. The competitiveness is shown in black

3.4. Assessment of the competitiveness of a specific brand of trucks

For the purpose of the survey experiments with Toyota brand were conducted as the leader in sales of trucks in the recent years (Table 11).

Comparison of the estimates of machines of a particular brand is subject to the following rules:

1. Assessments for each year of the period of global competitiveness are set;

2. For the first year of the period, if there is no brand-specific data in the sample of values the last available value for this brand is set;
3. For each year of the period for which no data is given the last available value of this parameter for the specific brand machine.

Table 11. Database values of the parameters of particular forklift models

Brand	Model	Year	Mass coef.	Engine power	Average speed	Gauge volume
Toyota	7FGK25	2001	0.683	28.0	14.25	5.428
Toyota	7FDK25	2002	0.663	40.0	17.75	5.428
Toyota	7FG25	2004	0.670	28.0	14.25	6.159
Toyota	7FGF25	2004	0.663	40.0	17.75	6.057
Toyota	60-7FD25	2005	0.651	44.0	19.75	5.965
Toyota	62-7FDF25	2005	0.651	44.0	19.25	6.309
Toyota	7FDF25	2009	0.644	49.0	19.25	6.309
Toyota	02-8FDF25	2012	0.694	41.0	18.75	6.057
Toyota	52-8FDF25	2012	0.685	42.0	19.25	6.057
Toyota	02-8FGF25	2012	0.702	38.0	17.75	6.057
Toyota	8FGCU25	2012	0.689	38.0	17.00	4.981
Toyota	02-8FGF25	2013	0.702	38.0	17.75	6.057
Toyota	02-8FDF25	2013	0.694	36.0	17.25	6.057
Toyota	52-8FDF25	2013	0.685	42.0	19.25	6.057
Toyota	06-8FD25F	2013	0.694	36.0	19.00	6.057

Averaging annual values and zeroing negative scores the following results are obtained (Table 12 and Figure 10).

Table 12. Annual values of the parameters of particular forklift models and their assessment values

Year	Annual mass coef.	Assessment	Annual average speed	Assessment	Annual output of engines.	Assessment	Annual volume of dimensions	Assessment
1998	0.644	**0**	19.250	**0.30**	49.0	**0**	6.31	**0**
1999	0.644	**0**	19.250	**0.30**	49.0	**0**	6.31	**0**
2000	0.644	**0**	19.250	**0.30**	49.0	**0**	6.31	**0**
2001	0.683	**0.143**	14.250	**0**	28.0	**1.0**	5.43	**0.61**
2002	0.663	**0**	19.850	**0.45**	40.0	**0**	5.43	**0.61**
2003	0.663	**0**	19.850	**0.45**	40.0	**0**	5.43	**0.61**
2004	0.667	**0**	18.975	**0.23**	34.0	**0.4**	6.11	**0.01**
2005	0.651	**0**	18.700	**0.16**	44.0	**0**	6.14	**0**
2006	0.651	**0**	18.700	**0.16**	44.0	**0**	6.14	**0**
2007	0.651	**0**	18.700	**0.16**	44.0	**0**	6.14	**0**
2008	0.651	**0**	18.700	**0.16**	44.0	**0**	6.14	**0**
2009	0.644	**0**	18.025	**0**	49.0	**0**	6.31	**0**
2010	0.644	**0**	18.025	**0**	49.0	**0**	6.31	**0**
2011	0.644	**0**	18.025	**0**	49.0	**0**	6.31	**0**
2012	0.693	**0.241**	19.506	**0.36**	39.8	**0**	5.78	**0.30**
2013	0.694	**0.255**	18.313	**0.06**	38.0	**0.1**	6.06	**0.06**

4. **Conclusions**

1. The conducted study shows that by 2008 there is some reduction in the relative technical competitiveness of the set of tested machines. In recent years, however, there was a slight increase in this value. These processes largely could be

explained by the global economic crisis and the emergence of many new manufacturers, especially from China, where the industry is seriously increasing, but in many cases with the cost of production quality. These statements would be subject to further study.

2. The made comparison of the technical competitiveness of the brand Toyota in terms of forklifts with load capacity 2500 kg shows that the competitiveness of these machines throughout most of the time is above the total. This is confirmed by the fact that Toyota's best-selling brand trucks for the last over 10 years worldwide, and over the last 45 years in Japan.

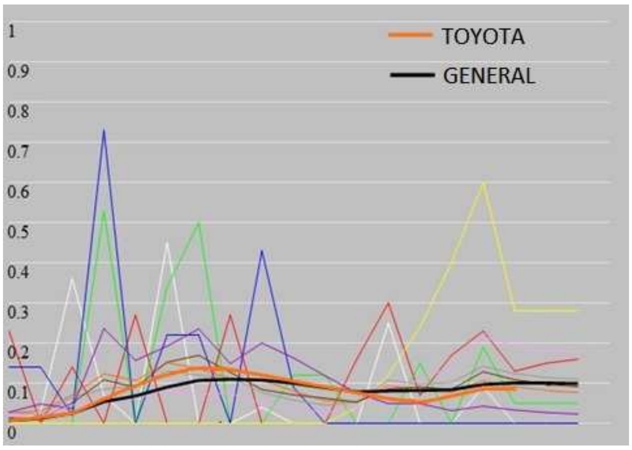


Figure 10. Graph of a comparable assessment of the technical competitiveness of the machines Toyota, with the general competitiveness

References

1. Tudjarov, B., Kazakov, N, Penchev, V. (2009) *A logistic system for discovering of the best way for cooperation through Internet engineering coordination center*. Proceedings of the XIX International Conference MHCL'09, p. 195-198, Belgrade, Serbia
2. Nonaka, I., Takeuchi, H. (1995) *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press, ISBN 0195092694
3. Kazakov, N. (2013) *One approach to achieving competitiveness of logistics equipment*. Proceedings of the International Conference "Management and Engineering 2013", ISSN 1310-3946, ISSN 1314-6327, p. 734-744, June 23-26, Sozopol, Bulgaria
4. Yankova, V. (2011) *Methodology for assessing innovative alternatives*. University of Ruse, ISSN 1311-3321, vol. 50, p. 129-133, Ruse, Bulgaria
5. Velev, M. (2004) *Оценка и анализ на фирмената конкурентоспособност* (*Evaluation and analysis of corporate competitiveness*). Softtrade, ISBN 954972588X, Sofia, Bulgaria
6. Nikolov, A., Kazakov, N. (2013) *Методика за оценяване на конкурентността на логистичната техника при прогнозирането ѝ* (*A method to assess the competitiveness of logistics equipment within it's forecasting*) BJED, ISSN 1313-7530, vol. 17, p. 33-38
7. Nikolov, A., Kazakov, N. (2014) *Determination of the basic parameters of forklift trucks when assessing their competitiveness*. Sofia, CAx Technologies, ISSN 1314-9628, issue 2, p. 39-47, Sofia, Bulgaria
8. Nikolov, A., Kazakov, N. (2015) Assessment of quantitative parameters of forklift trucks in forecasting and determination of competitiveness. INNOVATIONS IN DISCRETE PRODUCTIONS, ISSN 1314-8907, no. 1, Sofia, Bulgaria (in print)
9. Nikolov, A., Kazakov, N. (2014) *Methodological conditions for forecasting of the basic parameters of logistics equipment*. Sofia, CAx Technologies, ISSN 1314-9628, issue. 2, p. 67-81
10. Kazakov, N. (2014) *An approach to increasing the competitiveness of logistics equipment by optimizing the ergonomic requirements*. KSI Transactions on Knowledge Society, ISSN 1313-4787, Vol. VII, no. 4, p. 42-50, Sofia, Bulgaria
11. http://www.toyota-forklifts.eu/en/Pages/Default.aspx. Accessed: 21/02/2015
12. http://www.toyotaforklift.com/. Accessed: 24/02/2015
13. http://www.mitforklift.com/index.php. Accessed: 23/02/2015
14. http://www.forkliftaction.com/equipment. Accessed: 23/02/2015

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