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AN ANALYSIS OF DEMAND FOR THE SELECTED GROUP OF SPARE PARTS ILLUSTRATED WITH AN EXAMPLE OF FILTERS FOR AGRICULTURAL VEHICLES

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K e y w o r d s: spare parts, filters for agricultural vehicles.

A b s t r a c t

This paper contains presentation of problems of securing demand for spare parts for agricultural vehicles. Tasks carried out by a distribution and service company, which is the authorized dealer in the sector of agriculture service, have been characterized. The research was conducted for the group of parts including filters of: fuel, engine oil, oil for hydraulic system and gear box for JOHN DEERE agricultural vehicles. Selected parts were cyclically sold in connection with a change during the realization of technical inspections and post-technical inspections. The cycle of the conducted research encompassed the years 2003–2010. The research was carried out in the service department of the authorized dealer of agricultural vehicles of the DEERE & Company concern. The analysis of the number of sold filters in monthly, quarterly and annual arrangement was presented. The research results were statistically analyzed using the R program (v. 2.14.1.). The trend, random fluctuations and seasonal fluctuations for the series of monthly observations were determined. The analysis of the impact of works and agritechnical measures on demand for filters for agricultural vehicles was conducted.

Introduction

An increase in the competition on the market of farm vehicles and machines, reinforced by Poland's accession to the European Union, has caused intensive actions aimed at optimising the quality of customer service. Apart from the quality of offered products and their price, the ability to satisfy the clients' needs has become a dominant element of enterprise strategies. Recognising the expectations and preferences of future product users was carried out in order to develop procedures and satisfy the users' requirements through systemic solutions in the area of marketing logistics. Customer service, both in the pre-transaction and post-transaction mode, was modelled in such a way as

to meet the users' needs in the aspect of time, reliability, information exchange and convenience (CYPLIK et al. 2008, FRANKOWSKA, JEDLIŃSKI 2011, WOJCIECHOWSKI 2007).

Actions performed within distribution logistics include securing the demand of agricultural holdings in a wide range of fixed assets and their comprehensive servicing. According to market standards, the client requires the functional efficiency of products to be secured, and one of the conditions is the lack of time limits, quantitative and type restrictions in the implementation of spare parts purchase. The problem of financial encumbrances connected with the purchase of parts necessary for periodic servicing causes a considerable temporal variability of inspections, both within the warranty and post-warranty period. Authorised dealers conducting trade and services activity in the sector of services for agriculture implement strategies of long-term cooperation with vehicle users. Extending the distribution offer, they conduct comprehensive servicing involving check-ups and repairs of products made by particular producers according to the currently valid technical conditions (JUŚCIŃSKI, PIEKARSKI 2009e, RYBACKI 2011, SKROBACKI, EKIELSKI 2012).

The research problem

Securing the continuity of supplies of original spare parts, accessories and operation liquids was assumed as a standard on the distribution market of farm vehicles and machines. A specific feature of spare parts distribution is the possibility of establishing periodic contacts with the users of the products. In a long-term perspective, including the whole life cycle of a vehicle, the users need a wide range of elements for subsets and functional blocks. The sale of spare parts at present constitutes an important item in the income structure of distribution and services companies. Moreover, the sale of spare parts is an element stimulating the demand for servicing carried out by enterprises. Dealers, aware of the extensive market offer in the industry and mail order available to all users, make attempts to strengthen their market position among others by reducing costs within the outsourcing method (JUŚCIŃSKI 2011, JUŚCIŃSKI, PIEKARSKI 2009a, 2009b).

The issue of access to the group of spare parts with a significant and regular demand, which applies to filters for farm vehicles, is an important subject in the area of distribution logistics. The level and distribution of demand throughout the calendar year constitutes a significant problem in creating delivery schedules from plant warehouses.

The aim of the conducted research was to determine the quantitative structure of demand for the selected group of filters for JOHN DEERE

agricultural vehicles over a span of a calendar year and statistical analysis of demand by determining the trend, random fluctuations and seasonal fluctuations for the series of monthly observations.

The object of the survey was the authorised dealer of farm vehicles and machines dealing both with spare parts distribution and comprehensive servicing. The selected enterprise for over two decades conducts activities in the sector of services for agriculture in central-eastern area of Poland.

In the years 2003–2010 a selected group of spare parts was subject to the survey and analysis, including the following filters: fuel filter, engine oil filter, oil filter for hydraulic system and wheel case, used in vehicles produced by the DEERE & Company concern. The filters were selected for the survey because they constitute a specific group which, according to the producer's recommendation, are periodically replaced during warranty and post-warranty inspections of farm vehicles. It should be emphasised that trade and services enterprises are interested in connecting filter sale transactions with an inspection at a company service station.

The demand for inspections in the warranty and post-warranty period shows considerable variability in particular months of the year, which is determined by the method of using farm vehicles. A dominant group of vehicles are tractors used in field operations and work and for transporting agricultural produce. Such a model of operation in private holdings results in a relatively short period of intensive use of tractors, limited to agritechnical periods. Only tractors used in holdings as front-end loaders are characterised with longer and more evenly distributed periods of operation within a year.

The results of the survey of sales in the Sales Department in the years 2003–2010

The survey lasted eight years and includes the sales structure of 7393 filters for JOHN DEERE farm vehicles.

The distribution of demand between the following filters: fuel filter, engine oil filter, oil filter for hydraulic system and wheel case, used in the years 2003–2010 is presented in the histogram (Fig. 1). It should be emphasised that the first survey year was the second season of authorised sales of JOHN DEERE farm vehicles and spare parts by the given dealer.

In 2003 158 filters were sold. The demand in quarterly terms showed an upward tendency within the first three quarters. The demand at the beginning of the year was at a minimum level, and sales reached a maximum in the third quarter (Tab. 1). The lowest numbers of filters were purchased in January, February and March, and the largest numbers of purchases were recorded in August and September.

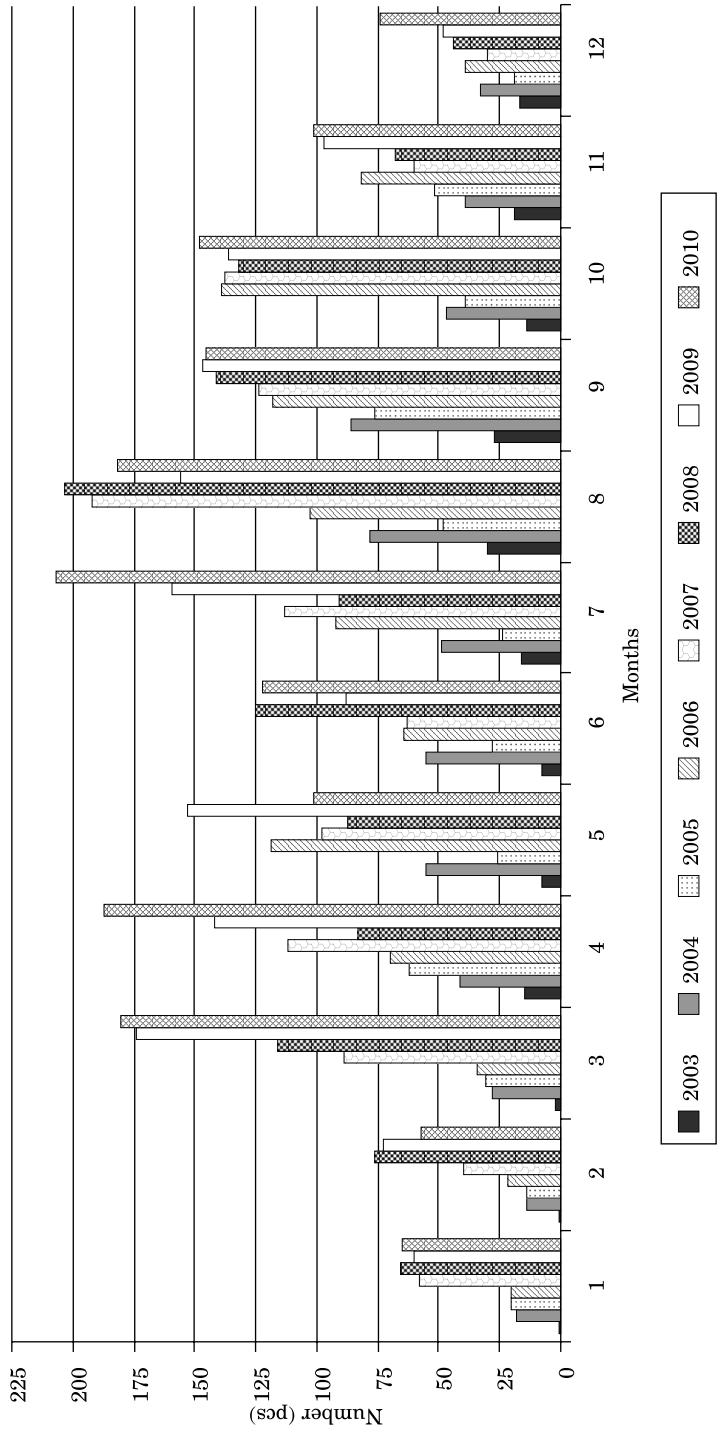

Fig. 1. The distribution of filters for farm vehicles from the surveyed group purchased in the years 2003–2010
Source: The author's own study

In 2004 users purchased 543 filters. The lowest demand was recorded in January and February. The sales of parts included in the survey were the lowest in August and September. The periodic analysis confirmed the upward tendency until the third quarter inclusive, when the maximum level of demand for the surveyed spare parts was recorded. In a year-on-year comparison an increase in sales amounted to as much as 243.6%.

In 2005 439 filters were purchased. In relation to the previous year, a decrease of 19.2% occurred. The lowest demand was recorded in January, February and December. The highest level of sales occurred in April and September. The maximum number of spare parts from the analysed group was purchased in the third quarter of the surveyed year.

Table 1

The sales structure of John Deere filters for far vehicles in the years 2003–2010

No.	The time of sales	Years [%]							
		2003	2004	2005	2006	2007	2008	2009	2010
1	I quarter	2.5	11.1	14.8	8.4	16.7	20.9	21.4	19.3
2	II quarter	19.6	27.8	26.4	28.1	24.5	24.0	26.7	26.1
3	III quarter	46.2	39.2	33.7	34.7	38.4	35.3	32.3	34.0
4	IV quarter	31.7	21.9	25.1	28.8	20.4	19.8	19.6	20.6
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In 2006 the Sales Department sold 902 filters. A minimum demand in quarterly terms was recorded at the beginning of the year, and the highest in the third quarter. In relation to the previous year, an increase in sales of 105.5% was recorded. The lowest demand for filters was in January and February, and the highest in May, September and October.

In 2007 the sales of 1117 filters was carried out. The quarterly demand was the lowest at the beginning of the year, and the highest in the third quarter. In comparison to the previous year, the sales increased by 23.8%. The lowest demand was identified in January and December, and the highest in August, September and October.

In 2008 vehicles users purchased 1232 filters. The lowest volume of purchases was recorded in January, November and December, and the highest in August and September. The analysis in quarterly terms showed a comparably low demand at the beginning and end of the year, and a maximum demand in the third quarter. In the year-on-year terms, an increase in transactions of 10.3% was recorded.

In 2009 1433 filters were sold. A low periodic demand was at the beginning and end of the year, and a maximum level of sales was reached by the Sales

Department in the third quarter. The lowest demand for parts subject to the survey was recorded in January, February and December, and the highest in March, May, August and September. In comparison to the previous year, the sales increased by 16.3%.

In 2010 clients purchased 1569 filters. The analysis in quarterly terms showed a comparably low demand at the beginning and end of the year, and a maximum demand in the third quarter. The demand for filters was the lowest in January, February and December, and the highest in March, April, July and August. In relation to the previous year, the sales increased by 9.5%.

The statistical analysis of filter sales in the years 2003–2010

The numbers of fuel filters, engine oil filters, oil filters for hydraulic system and wheel case were arranged in the form of monthly observations. They formed time series Y_t, subject to statistical analysis in order to assess the surveyed phenomenon in the distribution process. Changes in the structure of demand for filters were analysed in the aspect of work and operations applied in agriculture within a calendar year. The random variables obtained in the survey were subject to temporal sequencing in order to determine the trend, and random and seasonal fluctuations. The equalization of time series was done by using the method of aligned movable means. The lengths of moveable periods for the agricultural sector were $d = 12$. The analysis of sales filters was carried out with the use of the multiplicative model of time series components, which presents the correlation (ACZEL, SOUNDERPANDIAN 2008, PUŁASKA-TURYNA 2008):

$$Y_t = T_t \cdot S_t \cdot C_t \cdot I_t \tag{1}$$

where:
Y_t – the value of the series,
T_t – the trend of the series,
S_t – seasonal fluctuations,
C_t – cyclical fluctuations,
I_t – random fluctuations.

The times series consists of $t = 1, 2,..., 96$ observations in respective months $i = 1,..., 12$ for eight consecutive years of the conducted research.

The value of centred moving average $\bar{y}_{t_i}^{(d)}$ for the time series is described in the formula:

$$\bar{y}_{t_i}^{(d)} = \frac{1}{d}\left(\frac{1}{2}y_{t_i-\frac{d}{2}} + \sum_{t_i-t_0}^{t_i+t_0} y_{ti} + \frac{1}{2}y_{t_i+\frac{d}{2}}\right), \qquad t_0 = \frac{d}{2} - 1 \tag{2}$$

where:
y_{t_i} – empirical values of the series (the number of sold filters),
d – the length of the movable period, $d = 12$.

A matrix was created for the quotient of the empirical values of the series and aligned moveable means, in which the lines i are respective months and columns n are years of the conducted research. The index of average seasonalness of the particular i month is presented by the interrelation:

$$O_i = \frac{1}{c}\sum_{n=1}^{c}\frac{y_{t_m}}{\bar{y}_{t_m}^{(d)}} \cdot 100\ \mathrm{WK}^{(M)} \tag{3}$$

where:
n – the number of years of the conducted research $n = 1, ..., 8$;
c – the number of cycles of periodicity, $c = n - 1$
$\mathrm{WK}^{(M)}$ – the average multiplicative adjustment index to obtain $\sum_{i=1}^{12} O_i = 1200$.

The average multiplicative adjustment index was calculated on the basis of the formula:

$$\mathrm{WK}^{(M)} = \frac{1200}{\frac{1}{c}\sum_{n=1}^{c}\frac{y_{t_m}}{\bar{y}_{t_m}^{(d)}} \cdot 100} \tag{4}$$

The value of random fluctuations for the multiplicative is defined by the equation:

$$y_{t_i(\mathrm{skor})}^{(M)} = \frac{y_{t_i}}{O_i} \cdot 100 \tag{5}$$

For the surveyed series, the trend $\hat{y}_t^{(M)}$ was determined by using the weighted 5-period average according to the formula:

$$\hat{y}_{t_i}^{(M)} = \bar{y}_{t_i}^{(5)(M)} = \frac{1}{9}\sum_{t_i-2}^{t_i+2} y_{t_i(\mathrm{skor})}^{(M)} \cdot w_j \qquad \text{for } [w_j] = \begin{bmatrix}1\\2\\3\\2\\1\end{bmatrix} \tag{6}$$

Seasonal indices have an average value equal to 100%, which is a reference in the graphic analysis of the influence of seasonal fluctuations on the distribution of the set of variables. The statistical analysis of the sales of filters for farm vehicles was performed with the use of the R program, version 2.14.1 (CRAWLEY 2008, WALESIAK, GATNAR 2009).

Statistical analysis: the trend, random and seasonal fluctuations

The sales structure of filters subject to replacement during technical inspections of farm tractors in the years 2003–2010 had a variable structure (Fig. 1). The performed analysis of purchases provides grounds for formulating a thesis on the growing demand, with a simultaneous considerable differences in demand within each surveyed year. The level of demand from vehicle users had different values in the period of subsequent quarters of the year. The general rules was a lowered sales at the beginning and end of each year and a dynamic increase in demand in the third quarter. A comparison of the year-on-year sales results showed a rise in the number of filters purchased in most surveyed years.

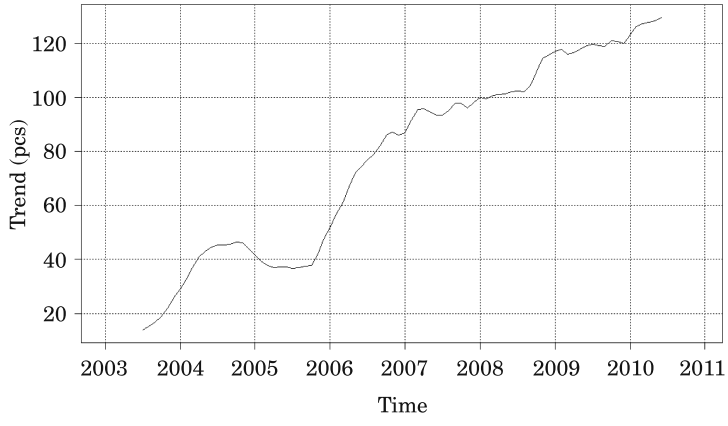

Fig. 2. The trend of the number of filters for farm vehicles sold from the group subject to the survey in the years 2003–2010

Source: The author's own study

Carrying out eight-year surveys of the distribution activities made it possible to define the trend which constitutes a graphic characterisation of long-term changes on the sales market relating to the selected group of filters for farm vehicles (Fig. 2). From 2003 to the third quarter of 2004, the trend was

increasing. At the turn of 2005 the trend decreased and the demand came to a standstill. From the fourth quarter of 2005 to the end of 2006, a trend with a high growth dynamics occurred. In the period from 2007 to 2010 a trend with a variable structure was recorded. The subsequent quarters saw a growing trend interchanging with periodic declines. Despite the trend adjustments, systematic growth was maintained and the maximum value was reached at the end of the surveyed period.

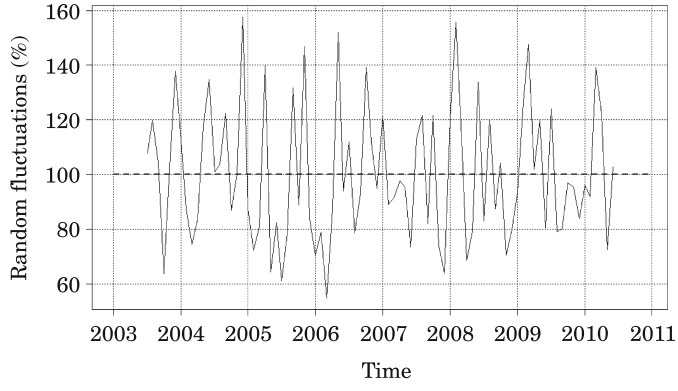

Fig. 3. The trend of the number of filters for farm vehicles sold from the group subject to the survey in the years 2003–2010

Source: The author's own study

The volume of demand changes for filters is presented in Fig. 3. The random fluctuations distinguished from the time series of filters sold make it possible to describe the variability of demand in the analysed market in particular months of subsequent years. The recorded changes reflect the dynamic increases of demand for the spare parts subject to the survey and the frequently occurring declines of demand. The course of changes in the years 2003–2010 is a proof of the unstable level of demand for filters from the surveyed group generated by farm vehicle owners. The highest value of random fluctuations occurred in 2005, 2006 and 2008.

The tasks carried out by distribution logistics require the preparation of a delivery schedule of spare parts. Random fluctuations occurring in filter purchases cause the changes in demand to reach minimum and maximum value in various months for particular years, which hinder the planning and carrying out of deliveries.

Eliminating the trend as well as cyclical and random fluctuations from the time series of the number of filters for farm vehicles sold made it possible to define the value of seasonal indices for several months in a year (Fig. 4).

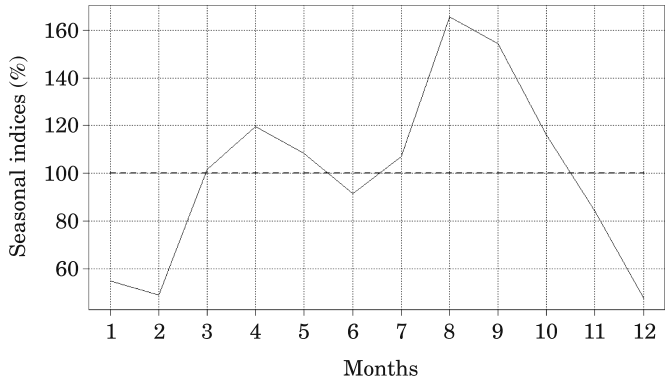

Fig. 4. The seasonal indices for the number of filters for farm vehicles sold from the group subject to the survey in the years 2003–2010
Source: The author's own study

Seasonal fluctuations influence the level of filter sales. In January and February, when field agrotechnical operations are not carried out, the number of filters sold was lower from the reference level by 45.1% and 50.9% respectively. The start of the season of farm vehicles use in March causes an increase of seasonal indices to the level by 1.6% higher than the reference level. As a result of seasonal fluctuation in April and May, the demand for the analysed spare parts grew above the average level by 19.7% i 8.3% respectively. The completion of spring field work coincided with a decline in the demand for filters by 8.4% below the reference level. The intensive operation of farm vehicles during harvest and collecting root crops generates demand for technical inspections. After a specific number of hours of operation it is necessary to replace the filters. Seasonal values cause that in July, August, September and October the indices reached a value below average, i.e. 7.1%, 65.5%, 54.2% and 16.0% respectively. In November and December, a high decrease in demand for parts was recorded, and seasonal indices were lower from the reference level by 15.8% and 52.3% respectively (JUŚCIŃSKI, PIEKARSKI 2008b, 2009c, KARCZMARCZYK 2005).

Conclusions

The sales of selected parts, for the group including filters of: fuel, engine oil, oil for hydraulic system and gear box for JOHN DEERE agricultural vehicles, displayed a growth dynamics at the level from several to several hundred percent in a year-on-year terms in as many as six surveyed periods. A comparison of the structure of demand for filters in annual terms for the years in

question from the beginning and end of the surveyed period showed an increase in demand by as many as ten times.

The sales structure of filters in quarterly terms indicated the lowest demand at the beginning and end of the year. An increase in the sales occurred in the second quarter, to reach a maximum in the third quarter of each surveyed year. This resulted in the implementation of warranty and post-warranty servicing inspections for the whole population of vehicles in the surveyed region. The servicing of tractors was carried out directly before using them for field work or right after intensive operation as a source of motive power for machines or traction energy.

The trend identified during the statistical analysis of the sales of filters for farm vehicles varied within the surveyed period. Years with an extensive increasing trend were dominant, and declines in demand did not last long. The value and dynamics of trend changes should be further analysed in order to develop systemic solutions for creating delivery schedules for distribution logistics. Getting to know the characteristics of demand for filters may constitute an additional source of information for planning the work in the company sales department providing technical servicing of farm vehicles.

The distribution of values of seasonal indices provides grounds for a hypothesis concerning the significant influence of the agritechnical work and operations on cyclical changes in demand for farm vehicles filters. The result of seasonal fluctuations is a high decline in demand for filters in the first and the last months of the year when field works are not carried out. A maximum increase of demand due to seasonal fluctuations occurs at the time of harvest and work in the field in autumn.

The statistical analysis of demand for filters was confirmed by the existence of considerable random fluctuations influencing the level of time series indices. The step increase of demand for filters selected to the survey requires the application of effective and efficient distribution systems or maintaining increased stocks. The phenomenon of unstable demand for selected spare part is a source of a number of organisational problems in managing the distribution chain.

The research on demand for filters of fuel, engine oil, hydraulic system oil and gear box oil and other groups of spare parts should be continued in a long period of time. Knowing the type structure and quantitative structure of the demand for spare parts for various brands of agricultural vehicles and machines will allow to optimizing processes in the logistics of the spare parts distribution.

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