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ANALYSIS OF THE AFTER-SALES SERVICE PROCESS USING DATA MINING – RESULTS OF EMPIRICAL PROCEEDINGS

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Purpose: The main purpose of the article was to present the results of the analysis of the after-sales service process using data mining on the example of data gathered in an authorized car service station. As a result of the completed literature review and identification of cognitive gaps, two research questions were formulated (RQ). RQ1: Does the after-sales service meet the parameters of business process category? RQ2: Is the after-sales service characterized by trends or is it seasonal in nature?
Design/methodology/approach: The following research methods were used in the study: quantitative bibliographic analysis, systematic literature review, participant observation and statistical methods. Theoretical and empirical study used R programming language and Gretl software.
Findings: Basing on relational database designed for the purpose of carrying out the research procedure, the presented results were of: the analysis of the service sales structure, sales dynamics, as well as trend and seasonality analyses. As a result of research procedure, the effects of after-sales service process were presented in terms of quantity and value (amount). In addition, it has been shown that after-sales service should be identified in the business process category.
Originality/value: The article uses data mining and R programming language to analyze the effects generated in after-sales service on the example of a complete sample of 13,418 completed repairs carried out in 2013-2018. On the basis of empirical proceedings carried out, the structure of a customer-supplier relationship was recreated in external and internal terms on the example of examined organization. In addition, the possibilities of using data generated from the domain system were characterized and further research directions, as well as application recommendations in the area of after-sales services was presented.

Keywords: after-sales process, data mining, after-sales data, process management, automotive.

Category of the paper: Research paper.

1. Introduction

New information technologies and changing expectations of prosumers determine the development of modern organizations in the automotive sector in after-sales service area (Alexander et al., 2002; Gaiardelli, Saccani, and Songini, 2007). Customers' expectations regarding the implementation of repairs and after-sales service are mainly associated with such parameters as quality (Farahani, Rezopour, Karda, 2011) and the length of the car maintenance service. In addition, it should be emphasized that the examined area of after-sales service in the automotive sector is assessed as four times larger than the sales area (Bundschuh, and Dezvane, 2003) and, according to R. Wise and P. Baumgartner, from the perspective of product life cycle analysis, after-sales service can generate up to three times more turnover than the value from the original purchase (1999). It should be understood that organizations operating in the area of after-sales services should compete in the space of business processes, at the level of which the following parameters can be measured: customer satisfaction, flexibility, productivity (Brewer, Speh, 2000; Gaiardelli, and Songini, 2007), costs (Kaplan, Anderson, 2003; Tornberg, Jämsen, Paranko, 2002), process maturity (Lockamy III, and McCormack, 2004; Sliż, 2018), process flexibility, as well as cycle time, functionally, reliability, usability, quality effectiveness and efficiency (González, Rubio, González, and Velthuis, 2010). Ensuring high level of parameters requires the design of highly flexible organizational structures that allows dynamic impact on exogenous impulses from a turbulent environment, but also endogenous factors that come both from those organizations and from within (Sanchez, Mahoney, 1996; Grajewski, Rybicki, 2016). One of the solutions to this problem is the implementation of a process approach, the level of which is determined using models for assessing the implementation of process orientation in an organization. To clarify, for organizations to be able to compete in process space, they should be classified at a minimum third level of maturity on a five-level measurement scale, defined as the state, in which processes are identified, formalized, but – above all – measured.

The development of information and communication technologies, increase of computing capabilities of modern computers and increase of access to tools enabling formalization, measurement, management and improvement of processes is the reason to use the achievements of information sciences in process management. One of the available techniques used by researchers is data mining, identified as "a process of discovering various models, summaries and derived values from a given collection of data" (Kantardzic, 2011, p. 6). More precisely, "data mining is the process of extracting interesting patterns and trends from large datasets". In this article, based on the obtained raw data, an attempt was made to apply data mining in order to extract interesting patterns and trends from large datasets, generated (Mansingh, Rao, Osei-Bryson, Mills, 2015, p. 193) in domain systems (in this case in the Dealership Management System). To sum up, the main axis of this article was an attempt to use data mining

using R programming language to analyze the effects generated in the after-sales service, on the example of an authorized premium class car service station.

The article formulates partial goals that interpenetrate in two planes: epistemological (TA) and methodological (MA). TA1: Identification of existing knowledge regarding management of the after-sales service process. TA2: Designing the theoretical model presenting the architecture of processes in an authorized service station from the perspective of reconstructed customer-supplier relations in external and internal terms. MA1: Attempting to build a framework for the measuring system of the process under study on the basis of data generated in the domain system for the management of authorized dealership.

2. Managing the after-sales service process – identification of cognitive gaps

2.1. Quantitative bibliometric analysis

Theoretical study was the starting point for addressing the problems described in this article. Scopus and Web of Science (WoS) Core Collection database resources were used to implement it. The parameters and results of this part of the quantitative analysis are presented in Table 1.

Table 1.
Results of quantitative bibliometric analysis

Base	Scopus base*			Web of Science base*		
Entry	Number of documents	Times Cited	h-index with self-citations	Number of documents	Times Cited*	h-index with self-citations
"after-sales"	283	1,551	21	152	920/809**	18
"after-sales" AND „management"	22	36	3	11	12/12**	3
"after-sales" AND „process"	16	55	3	7	4/3**	1
"after-sales" AND „data"	8	5	1	4	2/2**	1

*Search category in databases – article title. **Without self-citations. Available.

Source: Own study based on data obtained from the Web of Science and Scopus database, as of 17.04.2019.

Based on the performed quantitative analysis, a small number of studies presenting the issues of after-sales service process are visible from the perspective of its measurement, management and improvement, as well as few studies have been identified describing the possibilities of data mining and analysis generated in the after-sales service process.

2.2. Systematic review of the literature on the subject

At this stage of the analysis, it was noticed that the identified documents use two interchangeable terms: "after-sales" and "service", despite the fact that the term "service" should be considered as much more capacious and applies to a broader spectrum of studies related to service issues, not only after-sales services. It should be noted that, in the systematic review of the literature, keywords from quantitative bibliometric analysis were used.

Table 2 presents selected definitions of the term "after-sales".

Table 2.
Selected definitions of the after-sales concept

Author	Definition
M.A. Cohen, H.L. Lee (1990, p. 55)	"After sales service is the activity that supports products after they are delivered to customers."
Verstrepen, Deschoolmeester and Van den Berg (1999, p. 539)	"(…) the service after sales process encompasses all activities related to enabling existing customers to quickly locate, contact and activate the supplier's resources that are needed in order to create satisfactory product-related services, answers to inquiries or solutions to problems."
O.O. Ehinlanwo, M. Zairi, M. (1996, p. 41)	"After sales service could be defined as all activities geared towards maintaining the quality and reliability of the car carried out after the customer has taken delivery with the goal of ensuring customer satisfaction."

Source: study based on the indicated literature.

At this point, it should be emphasized that the after-sales service is identified in the literature with such terms as: after sale customer service (Urbaniak, 2001), after-sales service support (Loomba, 1996), after-sales service (Cohen, and Lee, 1990; Ehinlanwo, and Zairi, 1996; Asugman et al., 1997; Johansson, and Olhager, 2004; Gaiardelli, Saccani, and Songini, 2007; Saccanim, Johansson, and Perona, 2007), service after sales process (Verstrepen, Deschoolmeester, and Van den Berg, 1999; Patelli, Pistoni, and Songini, 2004), as well as mega-process of after-sales service (Sliż, Wojnicka-Sycz, 2019).

At this stage of the theoretical study, the first documents identified were the issues of measuring, managing and improving the after-sales service process. The study that most widely characterizes the after-sales service process in the automotive sector has been presented by O.O. Ehinlanwo and M. Zairi (1996). Also noteworthy is the research carried out by D.O. Valeria, E.A.P. Santos et al., who based on the use of the process mining method using the DISCO software, presented a map of after-sales service process, as well as identified and analyzed parameters related to the operation of cars, such as: mileage and customer reports (2017). Attempts to assess variables identifying defects in passenger cars generated in the warranty service process have been observed in the literature, based on which a proposal for data transfer model between the warranty service process and the car production process was presented (Sliż, Wojnicka-Sycz, 2019). Another study extensively presents the after-sales service process and characterizes the assumptions of the Lean After Sales Service concept, which aimed to improve the after-sales service process (Dombrowski, Malorny, 2016 and

2017). In turn, J. Werrmann presented a proposal to optimize the after-sales service process on the example of Mercedes-Benz dealership (2013).

Next, the studies for the query containing the terms after-sales and data were verified. A study was identified that used machine learning to analyze service data from production, control and after-sales service from various sources (Ko, Lee, Cho, H., Cho, S., Lee, W., and Lee, M. 2017).

Based on the results of the theoretical study, the following cognitive gaps were identified: the first – resulting from a small number of studies characterizing the after-sales service process, and the second – resulting from the lack of research, presenting the analysis of effects generated in after-sales service process in the automotive sector. The identified gaps related to the small number of publications covering after-sales service matters were also pointed out by P. Gaiardellia, N. Saccani and L. Songin (2007).

2.3. After-sales service as a business process

In this section of the article, based on key business process parameters (Rummler, Brache, 2000. p. 75; Kaplan, Norton, 2001, p. 43; Irani, Hlupic, 2002, pp. 5-10; Brillman, 2002, p. 286; Grajewski, 2003, p. 104), an attempt was made to define after-sales service in terms of business process. The parameters that were included in the assessment are:

- **Sequence of activities** – the after-sales process is determined primarily by the type of customer and the type of reason for intervention. It should be presented as a sequence of actions qualified for the following stages: customer acceptance, verification, diagnosis, repair, inspection and release of the vehicle to the customer. In addition, the stages of after-sales service concerning the diagnosis and repair are built largely of a procedure that sets out algorithms for actions designed by the manufacturer.
- **Client** – the client in the discussed issues is considered from an external and internal perspective (Brillman, 2002, p. 286; Grajewski, 2006; Harvey, Aubry, 2018). An external customer is defined as the one that outsources repairs or maintenance, while an internal customer has been defined as a functional area of team in the organization or company space ordering, for example, repairs related to pre-delivery inspection, additional fitting or interventions in new cars or warranty repairs payable by the grantor. (Figure 1).
- **External and internal supplier** – in the discussed set of after-sales activities of the suppliers, one should consider it, similarly to the customer, in internal and external terms (Figure 1). The analysis of the relationship of external and internal suppliers on the example of manufacturing networks has been characterized precisely by Feldmann and Olhager (2008, p. 141-149).

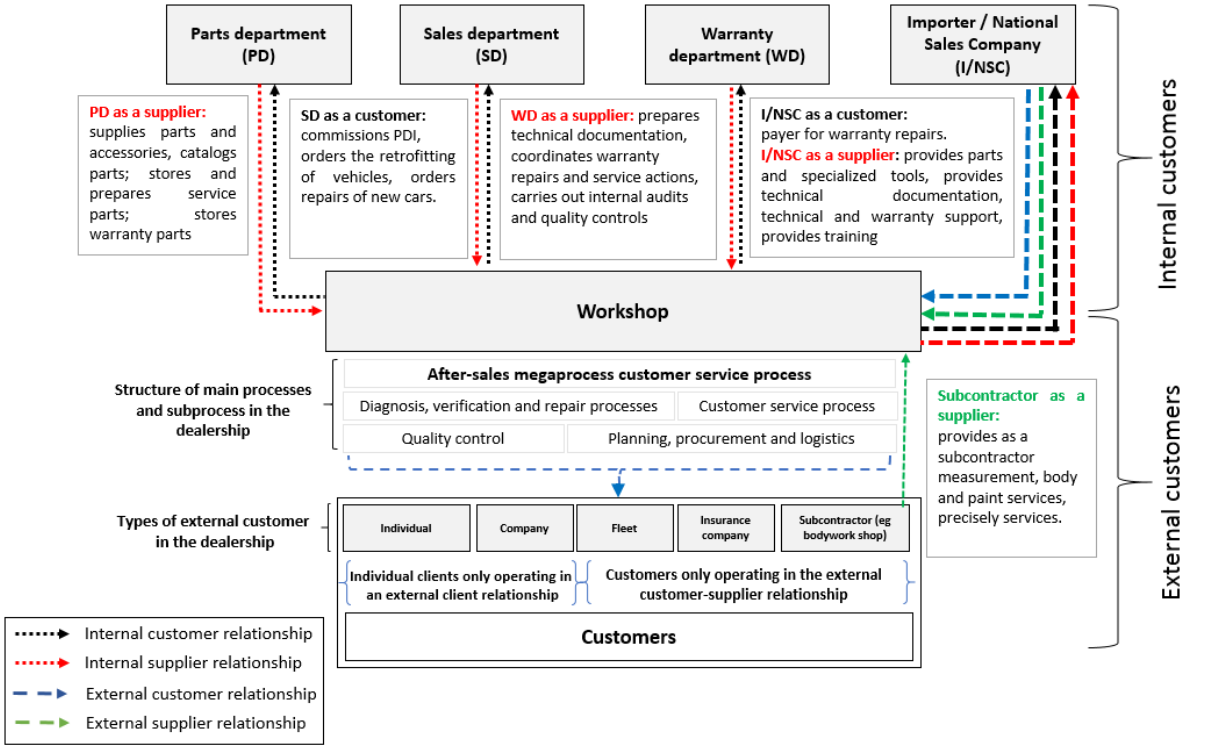
- **Inputs** – inputs to the described process are both tangible and intangible resources, which should include original parts and accessories, technical documentation, know-how provided by the importer or the manufacturer's representative on a given market.
- **Added value** – generated by actions in subsequent stages of processes, which can be calculated in the dimension of the result of the final effect (Cyfert, 2014, pp. 232-233), assuming that each activity should add a new value to the effect of an earlier activity (Porter, 1985, p. 3).
- **Outputs** – output from the process was identified as the end result, which should be understood as a service or a combination of a service and a product that meets customer's expectations. It should be emphasized that the shape of the final effect is primarily determined by the type of repair (inspection, warranty repair, body repair etc.), type of external customer (warranty repairs that must meet the standards of the manufacturer who is the payer and customer requirements in such categories as the length and quality of implementation).

To sum up this section of the article, the after-sales service process should be recognized in the business mega-process category, which crosses the organization in all levels of its functioning. It is a planned and highly standardized set of consecutive actions aimed at transforming the inputs – tangible resources (employees, tools, workshop and IT infrastructure) and intangible ones (knowledge, information, know-how) into tangible outputs, increased during the transformation with added value, in accordance with the requirements of external and internal customers. The after-sales service process should be identified as a set of activities with a low level of flexibility, due to the high level of standardization of activities and high level of participation of procedures during its implementation.

2.4. Model of a customer-supplier relationship in after-sales service process

Figure 1 presents a model of customer and supplier relations in external and internal terms on the example of an authorized car service station.

The model presented in Figure 1 allows, from the perspective of analyzing activities in an authorized car service station, primarily to identify customers and suppliers in external and internal terms, enables easier implementation of free market principles inside the organization, by understanding the reconstructed relationships between processes in the organization and designing a satisfaction assessment system for an internal customer in the organization.



*Relation I/NSC – Workshop was presented in four possible relationships, determined by the contract between the grantor and the licensee and the I/NSC structure. There are cases where I/NSC has its own dealer network as part of one organizational form.

Figure 1. The structure of a customer-supplier relationship in external and internal terms at the authorized service station under study. Source: own study based on a survey carried out in 2018-2019.

3. Materials and methods

3.1. Research framework

The methodological framework of empirical conduct was constructed based on ten successive stages of the study. These included: literature review regarding the implementation of after-sales processes in the automotive sector, determination of research area and research gaps, formulation of research objective, selection of the subject of research in a wide and narrow scope, analysis of process architecture and process maturity in the examined organization, analysis of the course of activities in the after-sales service process in the examined organization, selection of data for analysis from the measured after-sales service, design and construction of the elation database, data analysis, as well as summary of the study and formulation of conclusions. The study described in this article was carried out in 2018-2019 on a sample of 13,418 completed repairs in 2013-2018.

Empirical proceedings were carried out using the participant observation method. Confidential nature of the obtained data prevented the organization from being accurately characterized in this article. At this point, it can only be pointed out that the audited unit is an authorized service station for two brands of premium class cars belonging to one concern. Within the scope of implemented activities, it has a concession for their sale, service and sale of original parts. On the day of the survey, 30 employees worked in the organization in three departments: sales of new and used cars, service and spare parts. The structure of the examined organization is functional with the main processes identified.

3.2. Data

Only brands and models offered in accordance with the genotypic authorization of the tested unit were included in the analysis and design. Then, an evaluation attempt was made to identify distinguishing features of sold and serviced car brands. Assessment of driving parameters, body versions, customer segmentation and percentage share in the market structure allowed to draw the conclusion that there are significant premises indicating the need to distinguish the x_1 (brand 1) and x_2 (brand 2) brands in the analysis.

Based on the designated database, the structure of after-sales service was determined, with the division into intervention types, determined by the types of repair orders (Table 3).

Table 3.
Characteristics of the types of repair orders by customer type

Repair type/ Repair order type	Customer type	Characteristics
Body	External and internal customer	Orders for body and paint repairs.
Internal	Internal customer	Internal orders for repairs or interventions related to the repair of company or used cars. Complaints, the cost of which is covered by an authorized service station, are also settled in this type of order.
Normal	External customer	Normal orders identified as being paid by an external customer. They mostly concern mechanical and electrical repairs.
Salon	Internal customer	Salon orders are commissioned by the sales department mainly for additional fitting of new vehicles and carrying out pre-sales inspections (PDI; pre-delivery inspection).
Warranty	Internal customer	Warranty orders implemented for external customers, but settled with the warranty department of the importer or car manufacturer.

Source: own study based on the research carried out in 2018-2019.

The structure of repair order types presented in Table 3 will be identified later in the article as the structure of repairs carried out in the examined organization. It constituted the starting point for further analysis and enabled an attempt to answer the formulated research question, should the services provided in the examined type of organization be analyzed together or grouped by type of repair order (type of repair)?

3.3. Data structure in the after-sales database

The original database (raw data) contained 55 explanatory variables and 46,574 records. It should be emphasized that such a large number of records is determined by the database structure, generated in the DMS (Dealership Management System) domain system, in which each item in the sales document (sales invoice) was identified as a separate record.

First, all explanatory variables were analyzed, as a result of which their number was reduced to 11 variables (Table 4).

Table 4.
Characteristics of variables in the after-sales database after data cleaning

No.	Variable/attribute	Class	Variable characteristics
1	invoice_id	[character]	Unique number of the sales document.
2	order_type	[character]	Type of repair order.
3	order_number	[character]	Repair order number.
4	sales_VIN	[character]	Vehicle identification number (VIN)
5	sales_model	[character]	Car model.
6	invoice_date	[character]	Date of issue of the sales document.
7	record_net_value	[numeric]	Record value (net).
8	cost_value	[numeric]	Record cost.
9	invoice_profit	[numeric]	Record profit.
10	car_prodyear	[numeric]	Date of car production.
11	Brand	[character]	Product (car) brand.

Source: own study based on the research carried out in 2018-2019.

Then, raw data was reconfigured into a rational database and records were combined for individual items in the sales document to a state, in which one record was identified as one payment document, and thus one repair order.

4. Results and discussion

Based on the constructed relational database, containing data on 13,418 completed and implemented after-sales services in 2013-2018, an attempt was made to examine the following areas:

- Analysis of the volume of after-sales services carried out in quantitative and qualitative (value) terms using LOESS regression,
- analysis of the variability of after-sales services in quantitative and qualitative (value) terms for the x1 and x2 brands, as well as an attempt to compile the variability index for each brand by type of repair order (see Table 3),

- list of the structure of performed repairs, by type of repair order, in the examined organization for x1 and x2 brands,
- analysis of the trend and seasonality of maintenance services in the surveyed organization based on data from 2013-2015.

Data analysis was performed using the R programming language and Gretl software.

4.1. Analysis of the structure of after-sales services for x_1 and x_2 brands

Figures 2-3 present the number and value of interventions carried out in the after-sales process over the period under consideration. Time series analysis was performed using locally weighted non-parametric regression identified in the literature with the LOESS abbreviation (Cleveland, Devlin, 1988).

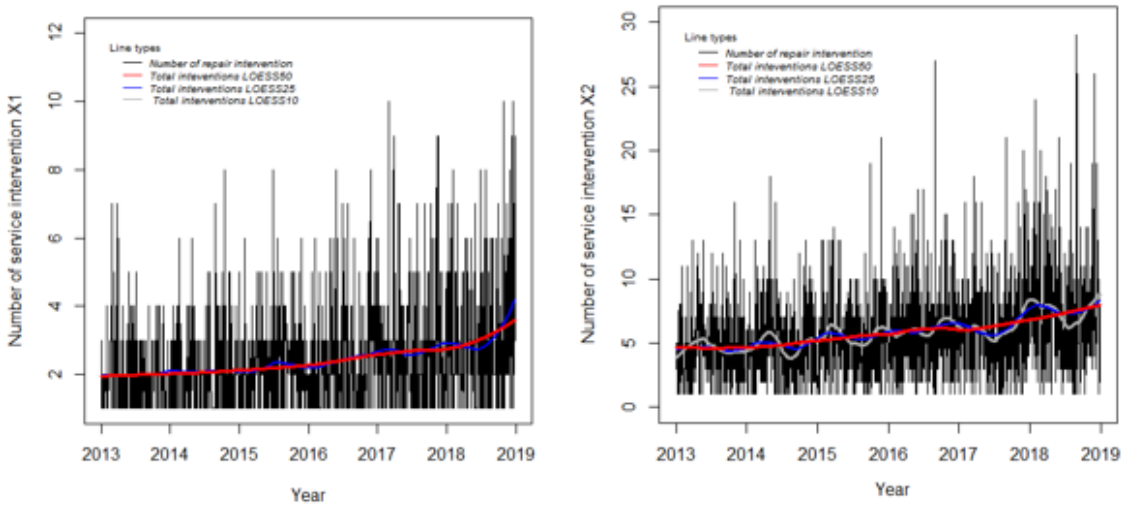


Figure 1. Summary of the number of after-sales interventions performed using LOESS regression for x_1 (2a), x_2 (2b) brands in the examined organization. Source: own study based on the research carried out in 2018-2019 using the R programming language.

Based on Figure 3, a clear upward trend is noticeable for both surveyed brands. Taking into account the value of repairs carried out, attention should be paid to x_2 brand, which has the largest share of the value and has a very strong impact on the total value of services sold in the examined organization.

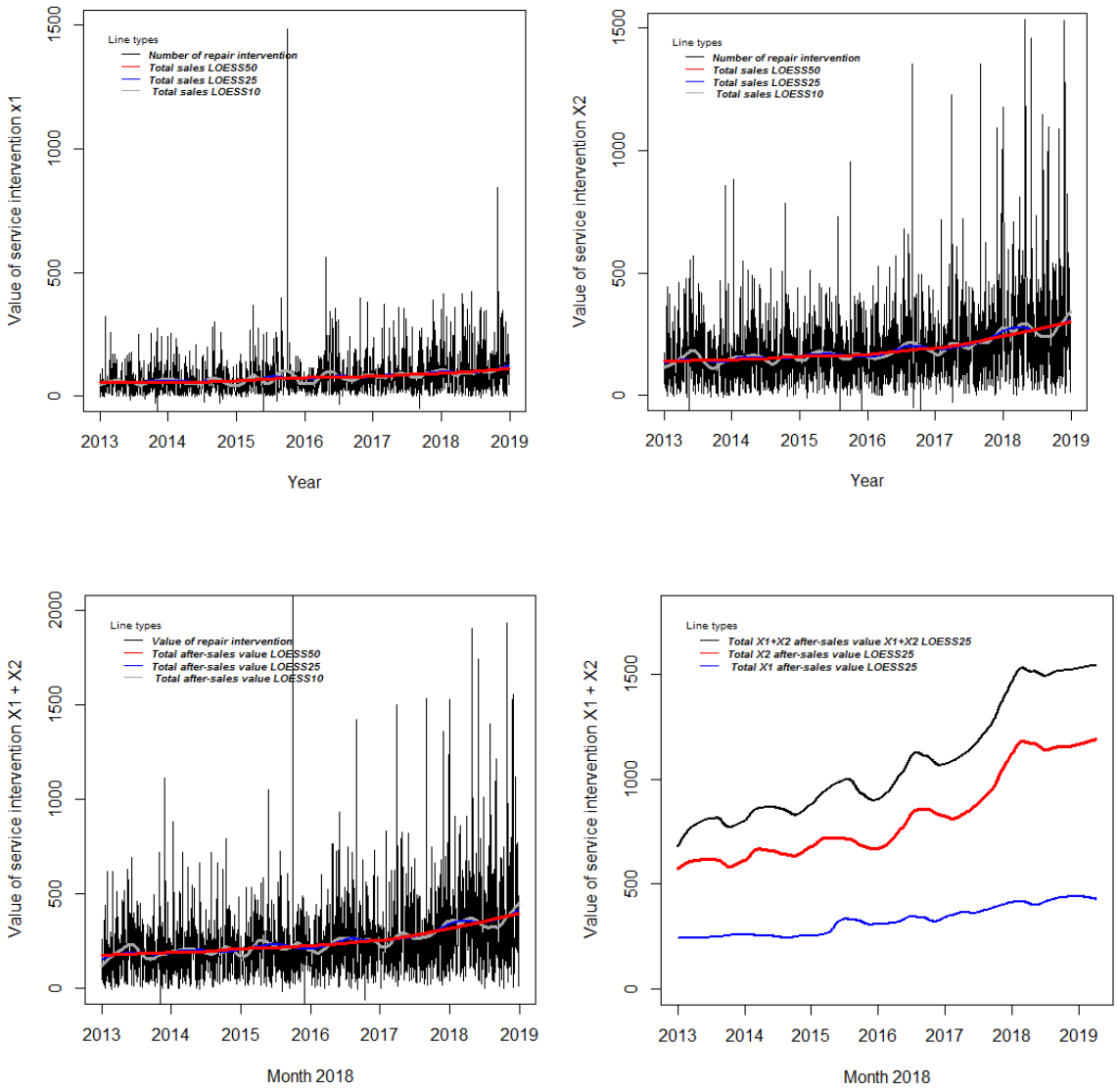


Figure 3. Summary of the value of after-sales interventions performed using the LOESS25 regression for the x_1 and x_2 brand in the examined organization (EURO). Source: own study based on the research carried out in 2018−2019 using the R programming language.

4.2. Analysis of variability of the examined process for x_1 and x_2 brands

Next, the coefficients of variation were verified for x_1 and x_2 brand, taking into account the number (Vas_q) and the value of intervention Vas_v (1).

$$Vas = \frac{s}{\bar{x}} * 100\% \quad (1)$$

where:

$Vasg_{xn}$ – coefficient of variation of the number of repairs for the analyzed brand (where $xn = x_1 ... x_n$),

$Vasv_{xn}$ – coefficient of variation of the value of repairs for the analyzed brand (where $xn = x_1 ... x_n$),

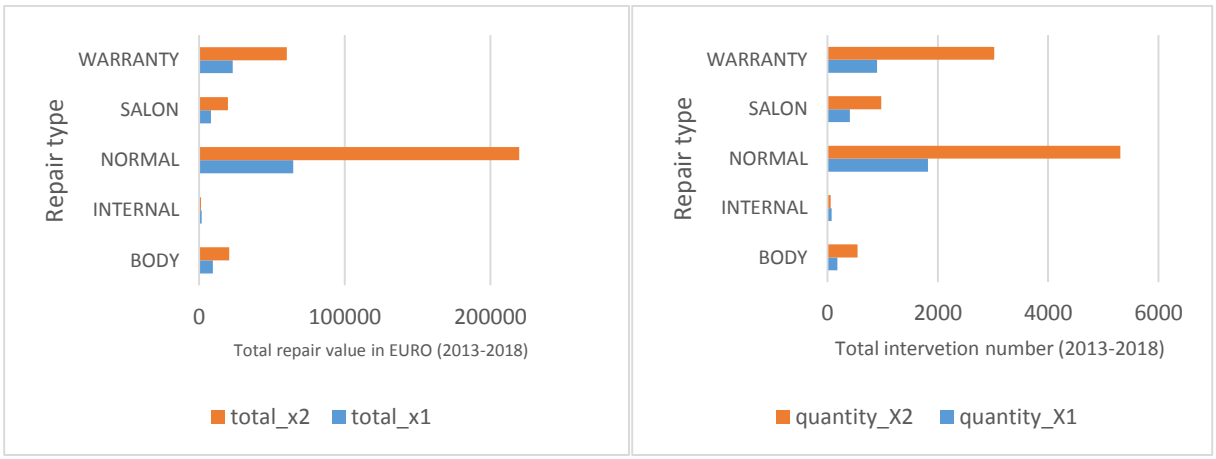
S – means standard deviation from the sample (per month in the studied period of 2013-2018).

$\bar{x}$ – arithmetic mean of the sample values (per month in the studied period of 2013-2018).

The results were as follows: $\mathbf{Vasg_{x1}} = \mathbf{0.653}$, $\mathbf{Vasq_{x2}} = \mathbf{0.634}$, $\mathbf{Vasv_{x1}} = \mathbf{0.153}$ and $\mathbf{Vasv_{x2}} = \mathbf{0.900}$. The obtained results of the *V* index show a high variability for both x_1 and x_2 brands. Similar results should be emphasized in terms of quantitative variability for both surveyed brands, which may be determined by the level of sales variability. At this stage of the study, no sales data was obtained, but an attempt to consolidate it between sales processes and after-sales customer service can be a reason for a more accurate verification of this phenomenon. What is noteworthy is the visible dispersion in quota values for the surveyed brands. In order to attempt to identify such a large difference between brands and a high level of variation for the x_2 brand, an attempt was made to perform a detailed analysis of variability, taking into account all repair orders carried out in the surveyed unit (Table 3).

4.3. Analysis of the structure of the studied process by the type of repair

Next, the sales structure of services was examined. To this end, repairs from the period of 2013-2018 were grouped to assess the share of individual types of repairs in the after-sales process (see Table 3). The results in quantitative and qualitative (value) terms are presented in Figure 4.



* The value only contains gross profit for the labour_profit variables. It does not include the external_labour_profit value, external_labour parts and profit_on_parts. According to the licensor's warranty policy, parts used for warranty repairs are sold without a margin.

Figure 4. Quantitative and qualitative structure of repairs in the examined organization. Source: own study based on the research carried out in 2018-2019.

The structure of repairs carried out in the examined unit presented in Figure 4 enables the determination of customer structure. The normal repair type indicates that both from the perspective of the number and value of interventions, the external customer service is dominant in the analyzed unit. The presented structure of the type of repairs indicates that the largest share of customers are external and internal customers, among whom the grantor has been qualified (IMP/NSC), as well as the warranty department and the sales department for new and used cars.

As a result of repair grouping, an attempt was made to re-analyze after-sales service variability. Table 5 presents partial values of the variability index in terms of quantity and value, broken down into the *order_type* variable.

Table 5.
Partial analysis of the coefficient of variation in terms of quantity (number of interventions) and value in terms of the type of repair order

Brand	Vx_1		Vx_2	
Order_type*	Quantitative	Value (amount)	Quantitative	Value (amount)
Warranty	0.5460786	1.514537	0.6551575	1.417086
Normal	0.5497376	0.9674219	0.5813828	0.8722113
Internal	0.2805223	2.730051	0.2124167	1.213555
Body	0.3410081	2.04602	0.5039339	1.508408
Salon	0.5368407	1.161284	0.6888005	1.242657

* Complaint repair orders were not included, due to the marginal share of this type of repair in the entire repair structure.

Source: own study based on the research carried out in 2018-2019 using the R programming language.

The results of the analysis of variability of repairs indicate a high variation in value due to the type of repair being carried out. In quantitative terms, the results of the variability of the number of repairs carried out should be considered similar, with a clear indication of higher variability for the x_2 brand. In turn, a higher level of variation was observed for the x_1 brand for warranty, normal, internal and body repairs. At this point, it should be emphasized that the sales share of the x_1 brand in the total sales volume of the analyzed entity is much smaller than in the x_2 brand.

4.4. Analysis of the trend in the number of car repairs of x_1 and x_2 brands

This section of the article estimates the analytical form of the trend model for the number of completed interventions (completed repairs) in the examined organization for x_1 and x_2 brands using the Ordinary Least Squares. The model includes explanatory t and t^2 variables, while the explained (dependent) variables for the presented models are characterized below:

$y_{afx1} -$ *the number of repairs carried out on* $x1$ *brand cars in* $2013 - 2018$

$y_{afx2} -$ *the number of repairs carried out on* $x2$ *brand cars in* $2013 - 2018$

The analytical form of the model is shown in record 2[1].

The statistics are in the critical area of distribution. The parameter standing at the time variable is statistically significant ($p \leq 3.63e\text{-}13$).

$$\widehat{y_1} = \underset{(2.13769)}{30.462} + \underset{(0.0508950)}{0.454225}t \quad (2)$$

In the estimated linear model, the arithmetic mean of the dependent variable was calculated = 47.04, as well as the residual error $S_{e,1}$ = 8.97, determination factor R^2 = 0.53 and the information Akaike criterion = 522.30.

[1] Critical value of the t-student's test $t_{0.05,70} = 1.99444$, value of the statistics from the sample $t_{\alpha 1} = 42{,}001$.

Subsequently, the square trend model was estimated, analytical form of which is presented in (3)[2].

$$\widehat{ysl}x1_t = \underset{(3.12)}{36.90} - \underset{(0.20)}{0.07}t + \underset{(0.002)}{0.007}t^2 \quad (3)$$

In the estimated linear model, the arithmetic mean of the dependent variable was calculated = 47.04, as well as residual error $S_{e,1}$ = 8.58, determination factor R^2 = 0.58 and the information Akaike criterion = 516.93. Then, the residual variance of the linear trend and square trend models were compared using the F test. To this end, the zero hypothesis (4) and alternative hypothesis (5) were formulated.

$$H_0: \sigma_1^2 = \sigma_2^2 \quad (4)$$

$$H_1: \sigma_1^2 > \sigma_2^2 \quad (5)$$

$$F = \frac{S_1^2}{S_2^2} = 1.09 \quad (6)$$

$$F_{0.05;70;69} = 1.49 \quad (7)$$

Comparing the estimated coefficients and the Akaike criterion, it should be emphasized that they are similar for both models, but due to the fact that $F < F_{\alpha,r1,r2}$, no grounds for rejecting the zero hypothesis were found. Thus, based on the collected data in the examined unit, it was found that the appropriate trend model for the number of cars sold is the linear trend model.

Then, the linear and quadratic trend model for the x_2 brand was estimated. The analytical form of the linear model is shown in (6)[3].

$$\widehat{ysl}x2_t = \underset{(4.25140)}{98.3048} + \underset{(0.101219)}{1.08374}\mathrm{t} \quad (8)$$

The statistics are in the critical area of distribution. The parameter standing at the time variable t is statistically significant (p ≤ 2.16e-016).

In the estimated linear model, the arithmetic mean of the dependent variable = 137.86 was calculated, as well as the residual error $S_{e,1}$ = 17.85, the determination factor R^2 = 0.62 and the information Akaike criterion = 621.30.

Then, the square trend model was estimated for the x_2 brand (7)[4].

$$\widehat{ysl}x2_t = \underset{(6.43)}{105.73} + \underset{(0.41)}{0.48}t + \underset{(0.005)}{0.008}t^2 \quad (9)$$

In the estimated linear model, the arithmetic mean of the dependent variable = 137.86 was calculated, as well as the residual error $S_{e,2}$ = 17.85, the determination factor R^2 = 0.63 and information Akaike criterion = 620.90. The values obtained in both models are comparable.

Comparison of the residual variance of the linear trend model with the residual variance of the square trend model using the F test. Hypotheses were formulated as in (4) and (5).

$$F = \frac{S_1^2}{S_2^2} = 1.14 \quad (10)$$

$$F_{0.05;70;69} = 1.49 \quad (11)$$

[2] Critical value of the t-student's test $t_{0.05,69} = 1.99495$, value of the statistics from the sample $t_{\alpha 2} = 2.73$.
[3] Critical value of the t-student's test $t_{0.05,70} = 1.99444$, value of the statistics from the sample $t_{\alpha 1} = 42.00$.
[4] Critical value of the t-student's test $t_{0.05,69} = 1.99495$, value of the statistics from the sample $t_{\alpha 2} = 1.53$.

Because $F < F_{\alpha,r1,r2}$ we have no grounds to reject the zero hypothesis. A suitable trend model for the number of x_2 brand cars sold, similar to the x_1 brand, is the linear trend model.

4.5. Analysis of the seasonality of the number of repairs of x_1 and x_2 brands

This section of the article estimates the seasonality model for the x_1 brand presented in the analytical form in (12).

$$\hat{y}_{tx1} = 30.6384 + 0.449405t - 4.23661Q_1 - 4.18601Q_2 - 0.968750Q_3 + 7.41518Q_4 - 0.200893Q_5 + 1.01637Q_6 + 6.40030Q_7 - 4.04911Q_8 - 5.33185Q_9 + 1.38542Q_{10} + 5.60268Q_{11} \quad (12)$$

Based on the obtained results, it was found that the parameters at variables Q_4, Q_7 and Q_{11} are statistically significant ($p <= 0.05$). The studied process is seasonal in nature. The decrease in the number of interventions occurred in April, July and November in relation to the average value of interventions per month in the period under consideration.

Next, the form of seasonality model for the examined x_2 brand was calculated and presented in the analytical form (13).

$$\hat{y}_{tx2} = 97.6821 + 1.10t + 2.19325 + 2.59246Q_2 + 9.49167Q_3 + 15.5575Q_4 - 6.04Q_5 - 7.64405Q_6 - 8.24484Q_7 - 11.6790Q_8 - 7.44643Q_9 + 10.1194Q_{10} + 6.68532Q_{11} \quad (13)$$

Based on the obtained results, it was found that the parameters at variables Q_4 and Q_8 are statistically significant. The studied process is seasonal in nature. An increase in the number of interventions was observed in April and a decrease in August.

Then, based on previous considerations, it was decided to verify the seasonality for both tested brands from the perspective of types of repair orders (Table 6). The results are shown in Table 6.

Table 6.
The results of the seasonality study of after-sales services by brand and type of repair orders in the analyzed unit in 2013-2018

Month	Brand	All types of repairs	Warranty	Salon	Normal	Internal	Body
Jan							
Feb					−4.12808*		
Mar							
Apr		7.41518**	3.16617*		6.21280***		−0.984623*
May							
Jun							
Jul	x_1	6.4003*			4.64077**		
Aug			−3.65526**				
Sep					−4.85169**		1.45685**
Oct							
Nov		5.60268*			5.48919**		
R^2		**0.64**	**0.61**	**0.46**	**0.39**	**0.35**	**0.23**

Cont. table 6.

Jan			6.49405*				
Feb				4.85357**			
Mar				4.60833*			
Apr		15.5575**			14.8859*		
May							
Jun							
Jul	x_2			−4.20595 *			
Aug		−11.6790 *				−0.700496*	−0.716063 *
Sep							
Oct					5.99306*		
Nov					7.20536 **		
R^2		**0.71**	**0.43**	**0.51**	**0.65**	**0.21**	**0.21**

*** - Significance level 0.01, **- significance level 0.05, * - significance level 0.1, final margins are given in brackets, R^2 = R-square determination coefficient.

Source: own study based on data obtained in the study using the Gretl software.

For the x_1 brand, no seasonality was recorded for the months of January, March, May, June and October, while for the x_2 brand it was May, June and September.

In search of deeper causes of seasonality, according to the author, one should build a model of data consolidation between the processes of selling new cars and after-sales service and, as a consequence, build an econometric model showing the impact of car sales on the structure of intervention in the after-sales service. This is the direction set by the authors in the next study.

5. Conclusion

On the basis of empirical proceedings, three generalizing conclusions were formulated based on empirical facts confirmed during observation. First of all, it was stated that the after-sales service should be identified in the business process category because it meets all its parameters. Next conclusion states that the repair services in after-sales service area in quantitative terms are characterized by a linear trend for both analyzed brands. Thirdly, the after-sales service is characterized by seasonality, which, in the authors' opinion, may result from the seasonality of new car sales. As a result of the described study, it was found that the analysis of after-sales services in terms of quantity and amount requires a separate look from the perspective of sold brands, but also the types of orders carried out.

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