APPLICABILITY OF PROCESS MINING TECHNIQUE AND HIDDEN OBSERVATION METHOD IN THE PRE-SALE AFTER-SALES PROCESS IN THE AUTOMOTIVE SECTOR

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Introduction

The development of modern information and communication technologies is primarily determined by an increase in computing power of computers, implementation of cloud computing, as well as an increase in the level of accessibility to these solutions. This implies a state in which the achievements of technical and information sciences are used in the discipline of organisation management. It should be understood that the possibilities of data analysis and exploration can have a positive impact on increasing the process orientation of an organisation, in particular in the area of formalisation, measurement and improvement of business processes. One of the available and increasingly used concepts is process mining, which allows you to diagnose problems not based on fiction, however, on the actual state of the organisation (Van Der Aalst, 2016). From a research perspective, access to organisational data is a significant limitation. This implies the need to search for new opportunities to obtain them and to ensure their high level of reliability and quality.

The research problem was formulated in the form of two research questions (RQ). RQ1: Is it possible to use process mining and hidden observation to reproduce and analyse a pre after-sales process? RQ2: What is the course of the pre-sales after-sales customer service at authorised service centres? In the first section of the article, as a result of a theoretical study, using a bibliometric analysis and systematic literature review, a cognitive gap was identified, and research goals were formulated. Next, the course of the research process and the structure of data generated in the data study are presented. In the next section, using the Celonis Snap tool, the results obtained regarding the course of the examined pre after-sales process were described and discussed, and data on the offers received were characterised using descriptive statistics.

The main axis of this paper is to demonstrate the applicability of process mining technique and hidden observation method to show realistically the course of the pre-sale after-sales process based on the automotive sector.

Theoretical study

The research proceeding began with the theoretical study using bibliometric analysis and systematic review of the literature on the subject, which identified a cognitive gap and formulated research goals.

Quantitative bibliometric analysis

This section of the article, based on the resources of the Scopus database, presents the summary of two bibliometric parameters for the 'process mining' entry: the number of publications and the number of their citations over the period considered. The LOESS (Cleveland, Devlin, 1988) regression was used in the time series analysis.

Among researchers dealing with process-mining issues, the largest share of the work was published by W.M.P. van der Aalst. In turn, verification of the authors' affiliations reveals the dominant research centre which is the Technische Universiteit Eindhoven (167) and the Pontificia Universidad Católica de Chile (38). The share of other research centres is less than 30 publications. The main research countries are the Netherlands (195), Germany (131) and China (120).

The assessment of the results obtained made it possible to formulate conclusions of a generalising nature:

- Data analysis in Figure 1 shows a growing interest (number of publications) in process mining.
- Process mining is interdisciplinary in nature. By far the largest share of published papers was recorded in the category of subject area to computer science (964), engineering (409), mathematics (334), decision sciences (227) and business, management, and accounting (196).
- The validity of the described problems is demonstrated by the structure of the document type, in which conference paper (803) and article (325) constitute the largest share. In addition, the assessment of the source type category has provided evidence that 509 papers have been qualified as conference proceedings, with a clear indication that process-mining is discussed during conferences related primarily to business process management, but also conferences devoted only to these issues.

Figure 1. Total summary of the number of publications (a) and the number of citations (b) using LOESS regression with the 25 base
Source: own study based on Scopus resources (access date: 09.03.2020)

- The importance of process-mining issues is also visible from the perspective of the funding sponsor category, because 284 out of 1177 identified documents contained information on funding.

Systematic literature review

Based on the set of identified documents in the quantitative part of the theoretical study, the focus was on studies regarding the issues of process mining in the Scopus category referred to as business, management, and accounting.

Based on the obtained data on events and processes it was also observed that a significant number of studies regarding the healthcare sector (Rojas et al., 2016). They mainly presented the possibilities of implementing process mining in healthcare (Mans et al., 2008a; 2008b; Batista, Solanas, 2019), analysis of business process (Rebuge, Ferreira, 2012; Erdogan, Tarhan, 2016), process modelling (Zhu et al., 2010), detection of fraud and abuse (Yang, Hwang, 2006). In addition, the possibilities of using process mining have been widely described by researchers in other sections on the example of anomaly detection in the financial sector (Bezerra et al., 2009), audit area (Jans et al., 2014), identification of coordination patterns in IT (Edgington et al., 2010) and the cost analysis and prediction for manufacturing process (Tu, Song, 2016). At this point, it should be emphasised that the number of process mining applications is much larger, which is why the studies with the highest level of citations are cited. In the space of the issues described in the automotive sector article and the possibilities of implementing process mining in it, two articles were identified regarding the conversion of data generat-

ed in the production process for their analysis using process mining (Dišek et al., 2018) and a study on the use of process mining in the after-sales service of the automotive sector (Valerio et al., 2017).

In turn, the problems described in this article related to the use of process mining and hidden observation, which is the possibility of obtaining information about events, has not been found. In the author's opinion, this is a cognitive gap, consisting in the lack of publications presenting the use of the concept of process mining based on data generated by the researcher during the implementation of hidden observation.

Research process and data

Research population

The research was carried out on a total population of 67 authorised car service centres belonging to the Polish dealer network of the „X” manufacturer. Empirical data was collected in February-March 2020. The dealership network in this article is defined as a set of authorised X brand service stations with a license for service and sale of original parts and consumables on a specific market. Information on the network has been verified based on the data provided by the SAMAR Automotive Market Research Institute. On this basis, a register of the examined organisations was drawn up and based on the data on the manufacturer's and individual authorised service stations' websites, information regarding the possession of concessions for after-sales service was verified and the contact e-mail address was provided to which the inquiry was sent.

At this point, it should be emphasised that the following criteria were adopted in the selection of the

dealer network: the size of the dealer network (> than 50 authorised service stations, websites containing contact details and the possibility of booking online service visits).

Characteristics of research process

Empirical proceedings were carried out using the hidden observation method and the application of process mining with the use of the Celonis Snap program. The study was divided into 4 main stages:

- selection of the dealer network and preparation of a register of authorised service stations belonging to it;
- selection of the study unit in a narrow scope, i.e. the car model and the scope of maintenance and repair activities;

- implementation of the study;
- analysis of obtained results and summary.

The detailed course of the research process has been presented in Figure 2.

While designing the research process, it was assumed that the condition for recognising the offer as complete is that the researcher obtains the answer to all the questions regarding the presentation of the price offer and presenting the fastest data of the visit in the service station.

Structure of the offer inquiry

The inquiry, addressed to the surveyed units via e-mail, concerned the operational service related to the implementation of the periodic review, replacement of engine oil, air filter element, fuel filter element and

Figure 2. Design of the course of activities in the research process

Source: own study based on a study carried out in 2020 using the BOC Adonis program

cabin filter. In addition, information was added about the need to replace the front pads and brake discs and one of the interior fittings: the gear lever. In addition, information was provided regarding a pre-identified fault in the form of symptoms related to engine noises that increase when driving under load. Information about the diagnostic error code that was identified during computer diagnostics was also added. Both the scope of the visit for the selected car model, the error code and the symptoms accompanying it were developed based on the recommendations of an automotive market expert. This means that in the space of the error described, this is a well-known fault, described in detail in the technical documentation of the X car brand manufacturer.

Moreover, in order to limit the number of messages regarding identification of the car, its detailed data was presented, which included: car brand, car model, engine version, VIN number and current mileage. At this point, it should be emphasised that all units received the same vehicle example.

Event logs structure

In the study, based on e-mail correspondence, a database was built, which was subsequently reconfigured into an event logs database in accordance with the Celonis SNAP program requirements (Table 1). The variables 'resource' and 'activity' in Table 1 were developed on the basis of Figure 1.

During the study, data on the following events was collected in the date and time format: sending a query to the surveyed units (the query was configured based

on the data on the opening hours of the surveyed service stations), receiving an e-mail with a reply to the first inquiry, preparing an offer (each of the offer documents contained data on the date and time of its preparation) and sending and receiving supplementary messages. The end of the examined process was identified as the date and time of receiving the complete offer together with the proposed data of the review and repair.

Results and discussion

This section focuses on presenting the results of the study. This chapter presents the happy path algorithm of the examined process, the main process parameters, the number and characteristics of process implementation variants, the actual pre-sales after-sales process map in the examined dealership population and the comparative analysis of the offers received.

Assessment of the pre-sales proceedings of the after-sales service process

Out of 67 identified organisations to which a request for quotation was sent, 36 complete offers were received. This means that 53.73% of the total population of the dealership brand X presented an offer for all commissioned repair services together with information on the next visit. In addition, it was observed that the e-mails posted on the websites are e-mails to service employees and are not carried out by the main reception, which

Table 1. An example of the structure of the generated event database in the study

CaseID*	Resource	Timestamp	Activity
Dealership_n	Researcher	20-02-13 6:42	Sending an email asking for an offer
Dealership_n	Researcher	20-02-17 11:33	Reminder for not responding to a message in the first email (III)
Dealership_n	Service advisor	20-02-17 11:57	Preparation of the offer
Dealership_n	Service advisor	20-02-17 12:03	Reply to email with reminder (III)
Dealership_n	Researcher	20-02-17 17:01	Sending an email asking to complete the offer (IV)
Dealership_n	Researcher	20-02-17 17:01	Sending an email asking to complete the offer (V)
Dealership_n	Service advisor	20-02-19 9:53	Reply to email with reminder (IV)
Dealership_1	Service advisor	20-02-19 9:53	Reply to email with reminder (V)

* n = dealership number

Figure 3. Algorithmic happy path

Source: own study based on the Celonis Snap program

may limit contact in the event of vacation or absence of the service employee. It is worth noting that most of the surveyed service stations do not use the autoresponder option, confirming the receipt of the inquiry and providing additional contact details.

For the pre-sales process under study, the following parameters were identified in the study: total number of cases per day – 1, total number of events per day – 35 and throughput time – 2 days, identified as the average case duration from process end without extreme outliers. Such a state was not achieved for any of the examined cases.

Figure 3 shows the course of the happy path algorithm. At this point it should be stressed that only 25.37% of cases flow via the happy path, i.e. only 17 organisations. The happy path throughput time was estimated at 2 days, however, it was not recorded for any of the cases.

Next, the assessment parameters were verified in the key statistics about users space. The following results were obtained: active user – 3 per day, events per user – 12 per day, cases per user 13 cases per user and user per case 2 users. A researcher (external customer), service consultant and an employee of the spare parts department was qualified to three users identified in the examined process. In most of the cases studied, the multi-task nature of a service advisor was noticed, who valued the

services, but also catalogued and valued the necessary parts and consumables. This was verified based on the message history and the person who prepared the offer (additional annotation on the document sent).

Figure 4. Course of the process for 61.8% of activities and 42.3% of connections

Source: own study based on the Celonis Snap program

Figure 5. The course of the studied process for 91% of activities and 70.6% of connections

Source: own study based on the Celonis Snap program

In the process analysis, using Celonis Snap, 10 variants were identified (9 identified and 1 other, containing 22% of cases). The first most frequently occurring in the sample of organisations is the variant, identified for 25% of cases, in which one additional inquiry about the offer was noted. Its implementation time is 0.2 days. The next variant for 18% of cases concerned the state in which the surveyed entity was asked to respond to the inquiry three times. The third variant concerned 12% of cases and presented a state in which no response was received after receiving the automatic message (autoresponder).

Figure 4 presents the course of the examined process for 61.8% of activities, starting with sending an offer with a question, its preparation and sending it to an external customer.

At this point, it should be emphasised that in the study using the adopted method, no actions related to the commencement of the valuation, vehicle history analysis based on the VIN number in the manufacturer's system were identified. There was no verification whether service actions were available for the selected VIN and the time needed to search for a place in the workshop schedule. The above-mentioned activities constitute the standard of after-sales customer service specified by the producer and should be implemented in each of the examined organisations.

In turn, Figure 5 shows the studied process for 91% of activities. The remaining 9% concerns research units in which an e-mail was sent asking to specify the offer four or five times. They constituted a marginal participation in the study (<10%).

Based on Figures 4–5 and based on the analysis performed in the Celonis Snap program, the activities that occur often, however, not necessarily being part of an optimal process included:

- Reminder for not responding to a message in the first e-mail (III) – in 37% of cases (26 events)

- Reply to e-mail with reminder (III) – in 16% of cases (12 events)
- Autoresponder – in 13% of cases (9 events)
- Sending an e-mail with a request to indicate the earliest available date (II) – in 12% of cases (8 events)
- Sending an e-mail asking to complete the offer (IV) – in 12% of cases (8 events)
- Replay to e-mail and sending missing offer information – in 10% of cases (7 events).

When analysing the above other frequent activities, there is a noticeable problem related to lack of response to the first inquiry, which resulted in the generation of subsequent reminders regarding the completion of the sent offer and the date of the visit.

31 organisations responded to the first question. The response was received the fastest after 0.1 h, at the latest after 28.7 hours. The average response time is 5.10 h. At this point, it is worth stressing that for all units the opening time of service stations has been verified so that everyone can respond at the same time. In addition, the time of sending the e-mail calculation of the mileage has been standardised with the opening time of the given service station. Data on opening hours was taken from the websites of the surveyed units.

The intervals between the unit's response and sending an e-mail on the research side should be indicated as the research restriction. This problem was eliminated by standardising the contact time with the studied unit by reducing the response time of the researcher to 1 minute for all units.

Analysis of price offers

This section of the article focuses on the effect generated in the examined process. Therefore, the author analysed the obtained offers. Out of 67 organisations, offers were received from 36 units, including 32 detailed offers with

Table 2. Event logs structure in the completed research proceedings

Variable*	Number	Mean	Median	Min	Max	Std. dev.
Total value of parts (net)	36	412.078	407.506	202.2401	676.0979	87.2801
Total value of parts (net) (without failure P1845)	36	274.564	266.559	175.4196	449.6177	55.94499
Total labour value (net) (without failure P1845)	36	150.610	148.31	48.95105	232.5175	37.23904
Total value of parts (net) (with failure P1845)	36	338.107	279.765	175.4196	898.6737	163.0979
Total labour value (net) (with failure P1845)	36	324.038	311.744	207.9744	603.9044	85.47102
Total without failure	36	562.689	571.027	322.5548	816.4242	97.35958
Total parts with failure	36	598.602	574.387	407.3147	963.0536	133.4879

*Amounts given in EURO

detailed items and 4 general offers containing main information on the price of the total part and labour.

In order to compare the offers, the hourly labour rate was harmonised, which is determined, among others, by the location of the object on the market. The arithmetic average value of the rate for man-hour in the studied sample is EURO 49.53 with the median of EURO 48.95). The minimum value read on the basis of submitted offers is EURO 9.79 and the maximum is EURO 101.40. The highest rates were recorded in units located in Warsaw, Wrocław, Poznań, Bydgoszcz, Katowice, and the Tri-City, and thus in large Polish cities.

First, the offers regarding the two variants were verified, the first one taking into account the costs of diagnosis and repair of the indicated defect, and without it. As a result of the statistical analysis, the basic values of descriptive statistics were obtained, which have been presented in Table 2.

Out of 36 organisations that submitted an offer, 27 presented the price of diagnostics of the reported problem, indicating that they could provide exact costs only after confirming the diagnosis. It should be emphasized here that the cost of diagnostics ranged from EURO 25.40 to EURO 185.31, with the arithmetic mean value of EURO 92.68 and the median of EURO 47.19. Other units in the examined sample presented the costs of repairs of the indicated defect including the cost of diagnostics. The total cost of repair was estimated in the range from EURO 132.66 to EURO 644.34, with the arithmetic mean of EURO 353.60 and the median of EURO 308.15.

Thus, a conclusion can be drawn that despite the unification of the hourly rate, a dispersion was noted in the price of services offered for both inspection and maintenance activities, as well as the removal of symptoms of the indicated failure. It is worth stressing that normative times and prices of parts should be similar within one network of authorised service centres. Lower prices may indicate the use of, for example, parts other than original ones supplied by the manufacturer or a large stock of materials purchased at lower prices, e.g. in previous quarters. In addition, there was a departure from the valuation standard in some cases, which should include all items listed with the number and amount of parts and labour used.

Conclusion

The main axis of this article was to present the possibilities to show realistically the course of the pre-sales process of after-sales customer service in the automotive sector using the hidden observation method and process mining. Based on the database of events created by the researcher, the concept of research procedure allows to compare its parameters against the background of other organisations operating in a particular automotive sector. On the basis of the completed research proceedings, three generalising conclusions were formulated. First, it was noticed that,

despite the assurances of car manufacturers and their regional representatives (national sales company), the possibility of receiving an operational repair cost estimate and making an appointment via e-mail was limited. This is evidenced by the fact that only 36 organisations submitted the offer and proposed the date of the visit. In addition, based on the reconstructed course of activities in the examined business process, it was noticed that despite the high level of standardisation of after-sales customer service activities in the automotive sector, only 25.37% of the organisations implemented them according to the happy path in accordance with the reference model of after-sales customer service via online communication. The third and final conclusion, the presented concept of process analysis additionally allowed the implementation of the utilitarian (application) goal, which was to present the possibilities of its application on the example of the studied sector in the form of reconfiguration of tests carried out by car manufacturers in the dealer network, examining such parameters as response time, compliance of the cost estimate with normative time, implementation of the customer contact standard and proposing additional services related to current marketing campaigns. In the author's opinion, the automation of the presented solution enables a dynamic assessment of the level of after-sales customer services using information obtained on the basis of event data. To sum up, the previous results obtained in the empirical proceedings are an incentive for further research on the possibility of using process mining and the method of hidden observation, as well as extending the approach presented in this article with the method of experiment in reconstructing the stages of business processes related to contact with external customers. The author's goal is also to carry out similar international procedures in other sectors, such as hotel services and e-commerce.

Managerial Implications

This research indicates that car dealership owners and after-sales managers in the automotive sector are at risk for customer attrition due to a lack of pre-sales after sales process compliance with the customer service standard designed by the car manufacturer. The presented study provides the automotive after-sales managers with the knowledge that the real process in the dealership is different than the reference process of after-sales customer service through electronic communication. For after-sales managers in the automotive sector reading this study, the critical take-aways would be in the ability to understand how a process-mining technique can help them manage and improve processes.

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Zastosowanie techniki eksploracji procesów i metody obserwacji ukrytej w analizie procesu obsługi posprzedażnej na przykładzie sektora motoryzacyjnego

Streszczenie

Celem artykułu jest przedstawienie wyników analizy przebiegu pre-sales procesu obsługi klienta posprzedażnego na przykładzie 67 autoryzowanych stacji obsługi samochodów osobowych w Polsce. Realizacji celu głównego przyporządkowano cele cząstkowe przebiegające się w dwóch płaszczyznach: teoriopoznawczej (TA) i empirycznej (EA). TA: Przedstawienie koncepcji i przebiegu procesu badawczego z wykorzystaniem obserwacji ukrytej i process mining EA1: Odtworzenie przebiegu i analiza pre-sales procesu obsługi klienta posprzedażnego w sektorze motoryzacyjnym. W realizacji badania wykorzystano następujące metody badawcze: ilościową analizę bibliometryczną, systematyczny przegląd piśmiennictwa, obserwację ukrytą i eksplorację procesów (process mining). W realizacji badania wykorzystano język programowania R, programy Celonis oraz BOC Adonis. Koncepcja oceny z wykorzystaniem połączenia process mining i obserwacji ukrytej, stanowi dodatkowy głos w dyskusji związanej z możliwościami wykorzystania process mining w oparciu o rzeczywiste zdarzenia generowane w badanych organizacjach. Jednocześnie zaproponowane podejście może niwelować błędy wynikające z subiektywnej oceny respondentów w sondażowym badaniu opinii. Proponowane podejście umożliwia ocenę organizacji bez konieczności udostępniania danych dotyczących przebiegu działań w organizacji. Bariery wynikające z przyjętej koncepcji dotyczą w szczególności ograniczenia badania do autoryzowanych stacji obsługi samochodów należących do jednego koncernu.

Słowa kluczowe

eksploracja procesów, obserwacja ukryta, proces obsługi posprzedażnej, motoryzacja