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ORIGINAL PAPER

APPLICATION OF PREDICTION MARKETS PHENOMENON AS DECISION SUPPORT INSTRUMENT IN VEHICLE RECYCLING SECTOR

Liliana Czwajda[1], Monika Kosacka-Olejnik[2], Izabela Kudelska[2], Mariusz Kostrzewski[3], Kanchana Sethanan[4], Rapeepan Pitakaso[5]

1) Polish Academy of Sciences, Warsaw, **Poland**, 2) Poznan University of Technology, Poznan, **Poland**, 3) Warsaw University of Technology, Warszawa, **Poland**, 4) Khonkean University, Khon Kaen, **Thailand**, 5) Ubonratchathani University, Ubon Ratchathani, **Thailand**

ABSTRACT. **Background:** The key players in the vehicles' recycling system are disassembling facilities, which manage flows of waste and reusable parts. The focus of the company's business activity lies in stream of reusable parts, which is the most valuable, considering possibilities of selling (economic value) and resources saving (ecologic value). As a result of conducted research problem with demand forecasting was identified, which was affected by the specific domain of business. The major objective of the paper was to present how to support demand forecasting on parts in disassembling facility with the use of predictive markets.
Methods: The problem area related to the demand forecasting in the disassembling companies was identified based on the previously conducted research and observations. The desk-research method was used to verify current knowledge on the forecasting methodology. Taking it into account, the predictive markets method was chosen in a specific research problem.
Results: In the paper, the idea of predictive markets was presented. What is more, general procedure of its implementation and practical application in supporting decision in disassembling companies were described.
Conclusions: Predictive markets which are based on the idea of crowdsourcing, use collective crowd intelligence, supporting many business areas, including automotive industry. The predictive market method was successfully adopted in disassembling facility in order to support decisions on demand forecasting of reusable parts. The main challenge in introducing predictive markets for enterprises application is IT support and that outlines direction for future research

Key words: predictive markets, disassembling facility, demand forecasting, spare parts.

INTRODUCTION

Among scientific research and papers connected to the automotive industry, there may be specified few groups of issues examined from the perspective of life-cycle stage of an automobile including i) development & manufacturing, ii) use and iii) disposal (end-of-life) (Figure 1), , however complexity of a certain product affects sophistication of interrelated flows and processes.

The recent technology development has led to challenges in the use of vehicles and their disposal (e.g. in considerably reduction of vehicles life cycles [Volpato and Stocchatti 2008]. The shortening of product life cycle in the automotive industry has resulted in a growing number of vehicles at the last stage, what in authors' opinion has not drawn a lot of attention of business and academia. On the basis of research experience, it was stated that the most challenging phase is end-of-life stage.

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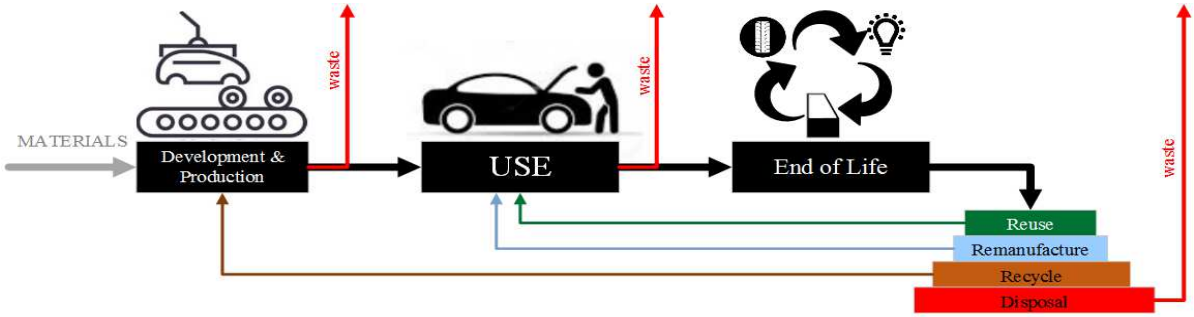


Source: own work

Fig. 1. Life cycle stages of an automobile

In previous research [Czwajda et al. 2017], it was claimed that automotive industry is one of the worldwide uppermost industry. Moreover, taking into account information about: influence of automotive industry in Polish Economy, role in the production of light vehicles in the Central Europe, total size of the vehicle fleet and age of the vehicle fleet, it was stated that there is high potential for vehicles recycling in Poland, particularly for disassembling facilities business (given in details e.g. in [Kosacka et al. 2016]). The company, which is investigated in this paper, represents a recycling sector as a disassembling facility, processing 1200 end-of-life vehicles (ELVs) per year, what makes it one of the biggest company in the recycling business in Poland.

With reference to Figure 1, authors recommended to use in the paper a ‘‘waste recovery hierarchy’’ proposed in [Gehin et al. 2008]. According to [Gerrard and Kandlikar 2007] reuse scenario should be preferable in terms of energy saving and environmental impact. In accordance to previous research, authors claimed that more than 60% of revenues of disassembling enterprises are created by selling used spare parts [Czwajda et al. 2017]. Customers are interested in purchasing used spare parts because of the lower price as well as possibility of obtaining parts which are no longer produced. To sum up, reuse scenario is the most lucrative part of disassembling company business, while it is also the most environmental friendly, however it has been also the most problematic what may be an effect of lack of demand forecasting on reusable parts, resulting in problems at the operational level.

On the basis of previous research [Czwajda et al. 2017], it was stated that demand forecasting of used parts causes many positive effects, not only economic but also social and ecologic. Thus, in the paper, there was proposed usage of virtual prediction markets to support decisions related to demand forecasting as an emerging problem area in conducting disassembling business. Authors believed that originality of work lies in proposed approach as well as object of research. In order to emphasize the essence of the issue a list of research questions (RQ1-RQ4) was prepared. The answers are presented in the next sections of the paper.

- RQ1: What methods are available for demand forecasting?
- RQ2: What is specific in demand’s prediction on reusable parts in a disassembling facility?
- RQ3: How to use prediction markets in disassembling business?
- RQ4: How to apply prediction markets in order to support disassembling facility processes?

The paper was organized as follows. In the Section 2 theoretical background of demand forecasting and practice in a chosen Polish disassembling company were presented. In the Section 3, basic information about virtual prediction markets were highlighted as an support for demand forecasting. In the Section 4, information about potential applications of prediction markets in recycling business were

included and guidelines for virtual prediction markets application were developed. In the conclusion, limitations as well as benefits from use of predictive markets in recycling sector were described. Moreover, authors have presented future research directions.

DEMAND FORECASTING IN DISASSEMBLING COMPANY

Demand forecasting – theoretical background

Demand forecasting plays essential role in the operations of each organization which would be integral part of actual supply chain. In general, it is understood as a process of predicting something, with considerations given to past trends, historical data and anticipated future occurring parameters. Forecasts are made over a selected planning horizons or study periods. In principle, it can be stated that their role is connected to decisions support in three primary planning horizons: operational (for one year), tactical (from one to ten years), strategic (from ten to thirty years), or in other way this planning horizons are connected to near-term, mid-range or long-range needs. The base for demand forecasting is methods based on statistics and econometrics. Forecasting methods can be divided into two main categories – qualitative and quantitative and are given in the Table 1.

Table 1. Forecasting methods and example of their usage in scientific literature

Qualitative	Quantitative	
Unaided judgement	Extrapolation	Box-Jenkins, AutoRegressive Integrated Moving Average
Judgemental decomposition (multiplicative decomposition)		Damped trend (damping a trend-series trend, damping seasonal factors, damping by averaging seasonality factor across analogous situations)
Expert survey (e.g. Delphi method)		Exponential smoothing
Structured analogies		Decomposed extrapolation
	Traditional and modified time series methods	Moving average, exponential smoothing (Single Exponential Smoothing, SES), exponentially weighted moving average (EWMA), adjusted EWMA, adjusted Holt and Holt-Winters methods, Croston method, Syntetos-Boylan Approximation (SBA), Poisson method, Grey prediction model
Game theory	Quantitative analogies	
Judgemental bootstrapping	Casual models	Segmentation
Intention survey		Regression analysis
Expectation survey		Index method
Simulated interactions (role-play)	Neural nets, Support vector machines	
Experimentation	Rule based forecasting and contrary series rule	
Experts systems	Methods of econometrics	
Focus groups	Data mining	
Scenarios	Big data analysis	
Conjoint analysis	Conjoint analysis	
Prediction markets	Computational simulation methods	

Source: own elaboration on the basis: Lawrence et al. 2009, Armstrong and Green 2017.

Group of extrapolation methods consists of Box-Jenkins, damped trend methods such as: damping a trend-series, which reduce forecasting error by almost 5% [Armstrong 2006]; damping seasonal factors [Miller and Williams 2004]; damping by averaging seasonality factor across analogous situations increased forecast accuracy by 7%, compared to using seasonal factors that were estimated individually for each precinct, according to [Gorr et al. 2003], the most widely used method of exponential smoothing [Gardner 2006] and decomposed extrapolation.

Traditional series method are subdivided into: moving average [Makridakis et al. 1998], exponential smoothing, exponentially weighted moving average (EWMA), adjusted EWMA for forecasting intermittent demand [Johnston and Boylan 1996], adjusted Holt and Holt-Winters methods [Altay et al. 2008], Croston method, Syntetos-Boylan Approximation

[Syntetos and Boylan 2001], Poisson method, Grey prediction model. Traditional time-series methods, such as moving average or single exponential smoothing are still the most used in business practices [Bacchetti and Saccani 2012].

Quantitative analogies methods are applied when analogous situation are available – it was proved by [Li et al. 2009] that this method was 2% more accurate than theoretical statistical ones, and 11% more accurate than usage of neural nets methods [Green and Armstrong 2012]. The neural nets were about as accurate as forecasts from established extrapolation methods [Crone et al. 2011] and more than 3% less accurate than damped trend-forecasts.

Casual models were applied in case of situations with large changes expected and in these cases they were more accurate than extrapolating methods [Allen and Fildes 2001]. One of the most often used methods of this group is regression analysis.

In the case of qualitative methods, given in Table 1., following can be mentioned. Structured analogies are methods that are formal and unbiased and they were 41% more accurate than unaided judgment. It is similar in the case of expert systems [Collopy et al. 2001]. Expert surveys, especially the Delphi method, avoid disadvantages of traditional group meetings – they were more accurate in 80% then the mentioned meetings [Rowe and Wright 2001].

Intention and expectation survey are often used for demand forecasting, however these methods needs similar questions in surveys to check participants answers due to their biases. Therefore, response errors in case of such are large component of forecasting errors.

The basic disadvantage of the qualitative techniques is subjectivism, however simplicity, clarity and low-cost, advocates in favors of those methods [Rosienkiewicz et al. 2017].To sum up, it can be claimed that it is difficult task to choose well-fitted forecast method and it depends on various factors, including: current market situation, the cost and time consumption of forecasts creating, and accuracy of particular forecasting methods.

In general, it can be claimed that with proper transposition of forecasting methods, each of them can be used in demand forecasting. According to [Armstrong and Green 2017], the problem is that many of these methods, are not sufficiently discussed in the literature. Armstrong and Green [2017] admitted that the most common reason forecasters avoid a scientific approach to forecasting is because the decision-makers have already made a decision and are only interested in information to support that opinion. However, it is worth noting that the degree of matching of the methods to certain aspects of defined problems and the size of the prediction errors may be different depending on the problem which is under consideration. Much also depends on the degree of accuracy of particular method used in order to predict some phenomena. An unambiguous designation of the method, that best suit to forecasting problem, requires in-depth studies and using the same data for subsequent forecasting methods. Such a task has a long time horizon, so the authors of the paper decided to start this type of research from the implementation of the prediction markets method.

The above considerations constituted an answer to the research question RQ1.

DEMAND FORECASTING IN DISASSEMBLING COMPANY – STATE OF ART

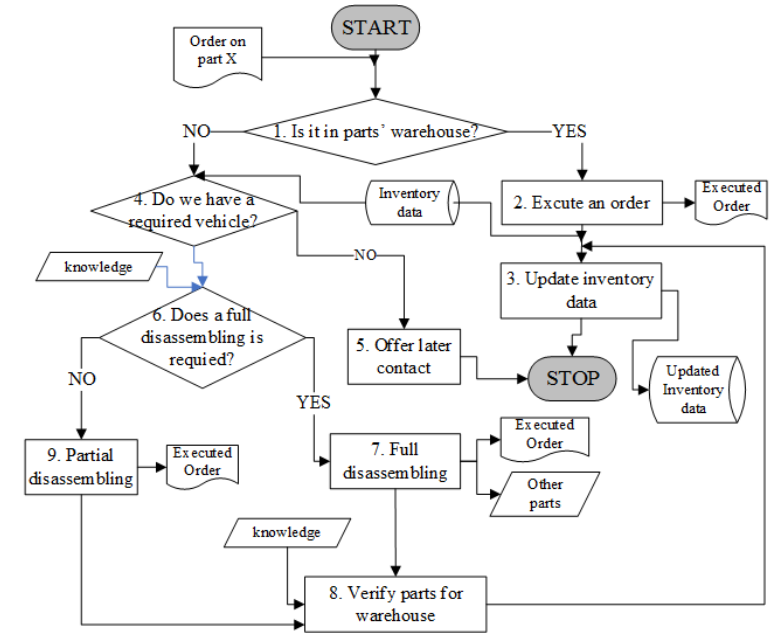
Regardless of the geographic location, disassembling companies play a crucial role in recycling network and they have to deal with illegal recycling business, what in details was presented e.g. in [Kosacka et al. 2016]. Considering the high importance level of the disassembling facility and demand forecasting, in this section, there was described a demand forecasting process.

Taking into account the fact, that reusable parts determine majority of disassembling

company's profit, authors stated that the company should be focused on that material flow. The flow of parts determined for reuse scenario is affected by law requirements, because of safety factors, so there is a catalogue of parts not allowed to reuse [Directive 2000/53/EC].

Authors claimed, that considerations about reusable parts obtained from vehicle's disassembling should be always made in relation to product (vehicle) and the demand on new parts, because they demonstrate similar sale features. The list of factors affecting requirements and realization of management and demand forecasting were presented in [Czwajda et al. 2017].

The company considered in this paper is a typical representative of the disassembling companies in Polish recycling sector. The major rule determining the disassembling process is availability of parts according to customer's demand (time, quantity, technical conditions). In the Figure 2 execution of customers' orders was presented.



Source: own work

Fig. 2. Execution of customers' orders

When the order appears, the availability of particular part is verified in the company's inventory. Reusable parts are object of interest not only by end-users, but also some institutions including automobile shops or workshops. There are used two business models of parts sale, including direct sale from disassembling facility and the use of Internet distribution channel (via Internet, social media, automobile's forum). In order to save the space and fulfill legal requirements, in disassembling companies there are warehouses for parts dismantled from ELVs, however there are also full ELVs on stock. When the order is received, the part's availability is checked. Firstly, there are verified inventory in a warehouse of parts, secondly ELVs in stock. When the requested part is out of stock, company offers customer to contact later. If the part is available, in the first place it is sold from the parts' stock in the warehouse, in other case it is removed from stored ELV. Sometimes, in order to get to the particular part, there have to be made a full disassembling of a vehicle, what engaged a company's worker. Each disassembled part is tested in order to check the technical efficiency. If it is good, part may be sold, in other case it is verified in order to be repaired/refurbished.

The scope of disassembling, used methods and tools is determined by customer's needs, part's technical condition and implicit

knowledge of the employees about market demand [Czwajda et al. 2017].

In author's opinion the major problem is that, the last factor is the most influential, what makes the disassembling process dependent on subjective opinions of workers. Moreover, the company may have a direct impact on employees and it may indirectly affect the technical condition of parts, however there is lack of influence on the market demand. Although, the knowledge of the market is available (e.g. sales figures), it is not used to predict future demand. In the result, in may cause wrong decisions made on warehousing.

To sum up, authors stated that:

- there is lack of methods or tools used in order to forecast market demand,
- the most frequently used data source for making decisions on parts in stock is implicit knowledge of employees,
- demand forecast affects decisions on inventory management what has an influence on company's profit, environment condition and people's comfort due to the resources consumption.

Authors claimed, that demand forecasts are not a goal in and of itself, but they may be a tool supporting the planning and management of various aspects of disassembling company business. To sum up, it was claimed that in presented consideration, there was explained specificity of demand forecasting for reusable parts in disassembling facility, according to RQ2.

PREDICTION MARKETS AS A DECISION SUPPORT TOOL - ORIGIN OF PREDICTION MARKETS

Prediction markets are based on the crowdsourcing research methodology [Czwajda et al. 2017]. Crowdsourcing is the process of using the potential of knowledge and a virtual community for solving business and social problems. It requires creating easily accessible and intuitive tools that support interaction [Przybyła and Sobczak 2010]. It is based on the will of users, participating in a given project. An important aspect of this process is the motivation e.g. in the form of prizes. In this case, carefulness is required to not make it process of "buying participants" opinions In practice, crowdsourcing includes a lot of different activities described in: [Grela 2014].

However, the concept itself is not new, the growing importance of the Internet and the increase of modern technology, has opened new possibilities for the use of this tool. There are currently 14 key areas of crowdsourcing use, that are presented in Table 2. The original definitions of crowdsourcing significantly narrowed the possibilities of using this solution. This tool allows to acquire knowledge, ideas, content or solutions to problems in a faster, cheaper and better quality, than traditional models.

In the paper, there were used prediction markets to solve the problem of forecasting demand on parts.

On the predictive markets, platform users try to predict the probability of certain events. Literature research shows that the predictive market gives the possibility of better assessment than questionnaire surveys. This is the result of asking participants not only to perceive reality, but also to estimate probability of the event appearance on the market. Considering that, it was found that such approach requires a rational look at the facts and gives the opportunity to assess the event that affects the outcome of the market event [Wolfers and Zitzewitz 2004]. The advantage of predictive markets is so-called wisdom of the crowd, that leads to use of a diversified knowledge.

However, there are a lot of advantages of predictive markets use, authors of the paper are aware of weakness related to crowd's requirement. If the number of players is small, the answers received will not be so reliable. Moreover, there is also the risk of market manipulation, when access to the market is too easy, however this aspect is not covered by literature.

Table 3. Possibilities to use crowdsourcing

Type	Principle of operation	Example
CrowdIntelligence	Collective intelligence of the community.	Quora
Open Innovation	Using resources outside the company's direct environment, in order to create innovative solutions.	Procter&Gamble PG Connect+Develop
Crowd Causes	Units or charities supporting projects aimed at social welfare-oriented aid.	XPrize
Crowd Tasks & Creativity	Projects aimed at performing tasks, providing services through a large and dispersed internet community.	Amazon Mechanical Turk
Social Business	Companies focused on authentic listening, engaging through open social channels.	Dell
Customer Co-creation	Cooperation between the company and the consumer group focused on developing a joint solution.	Company Citroen
Citizen Engagement	Involving residents to jointly manage the city.	WeDundee (Scotland), Open Warsaw Project
Mass Collaboration	Independent cooperation of a large number of users on the one project.	Wikipedia
Online Communities	Internet communities characterized by a high interaction rate between them, which share a common idea, interest or idea.	Reddit platform
Sharing economy	An economy based on sharing.	Uber Organization, Hotel Airbnb
Non-Equity Based Crowdfunding	The members of the community financially support the project or project in exchange for the rewards of being able to use the service.	Kickstarter platform
Equity-Based Crowdfunding	Community members become shareholders of a project or project.	Crowdcube
Peer-to-Peer Lending	Social lending money without the participation of a financial institution.	Lending Club
CrowdCurrencies	Alternative currency systems created by online communities.	Bitcoin

Source: own on the basic of Kasprzycki-Rosikoń, 2016

In recent years, there has been a dramatic increase in research using predictive markets. They were used in predicting: future events, presidential elections in the USA [Forsythe et al. 1992] anticipation of the Taiwan epidemic [Tung et al. 2015] and in supply chain management [Hedtrich et al. 2009]. Prediction markets are commonly used in a business practice e.g. by companies such as: Hewlett Packard [Ho and Chen 2007] or Microsoft [Grela 2014]. In Poland, in 2014, the Agency for Industrial Development S.A. and the Center for Applied Mathematics and Systems Engineering PAN launched the prediction market, which has been used to predict the development of modern technologies with particular emphasis on grapheme [Czwajda et al. 2017].

PREDICTION MARKETS IMPLEMENTATION – CASE STUDY

In the Introduction, there were mentioned factors proving problems with demand forecasting for reusable parts, including lack of impact on input material stream (ELVs), influence of limited space, subjective decisions of employee's on the basis of their implicit knowledge, and at almost marginal access to information on market demand. Considering the fact that, there is lack of access to the records of sold parts, it was claimed that, the possibility of analysis and verification of the quantity of stored parts/vehicles is decreasing. Prediction markets are specific forecasting tools, which use the implicit knowledge of their users to predict the occurrence of various events. What is more, in order to verify the forecasts obtained from the markets, there may be used data given from reports, statements and intermediate data, with appropriate references to the subject of the event.

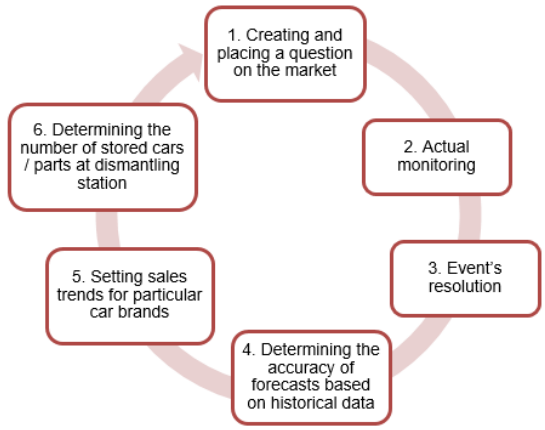
The diversity brands and models of vehicles intended for re-use has a vital impact on disassembling business. In the examined enterprise there are on average about 100-200 different vehicles ("temporary warehouse") and about 40 types of different parts, that can be obtained from one vehicle [Czwajda et al. 2017]. Considering that, it was stated that there is a need for solution dedicated for demand on spare parts forecasting.

The market for demand forecasting for vehicle's parts/vehicle, consists of the following elements:

- precisely defined object to be foreseen,
- market's participants,
- set of rules,
- network communication platform available for project participants,
- market provider that defines, enforces and maintains an internet platform.

The prediction market has been used in the presented research.

It was stated, that prediction markets may be used not only for forecasting trends of the new technologies development in the automotive industry, but also for demand forecasting on parts from stored vehicles (ELVs).



Source: own work

Fig. 3. Ideological scheme of using the functionality of the prediction market to determine the number of stored cars / parts at disassembling enterprise

With reference to Figure 3, there were determined six steps necessary to use the functionality of the prediction market in the research on disassembling company, including:

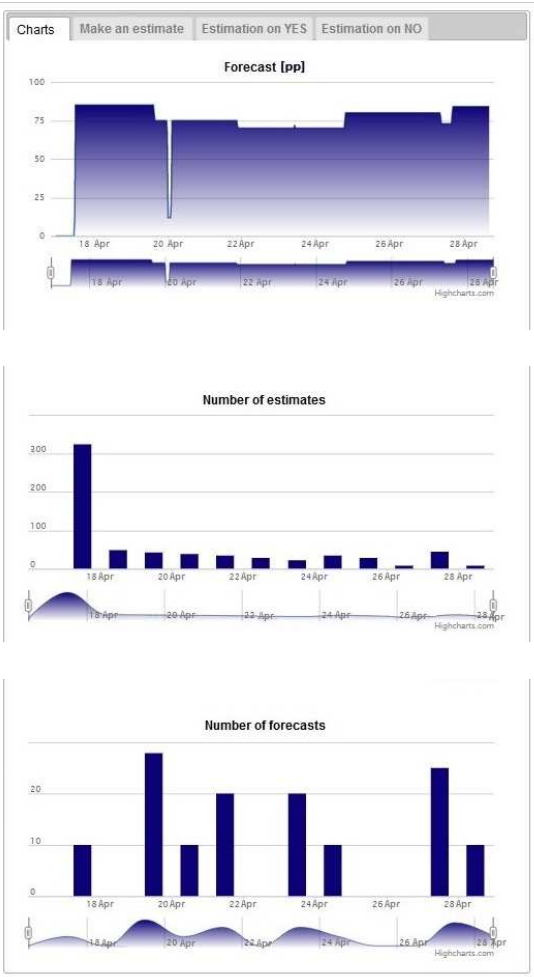
Step 1. Creating and placing a question on the market

- The research was carried out on the currently operating research predictive market and consisted of the following steps:
- A representative group of users consists of: dismantling company employees who are responsible for the dismantling process and the distribution process – these people have knowledge about the market demand for particular parts (treated as experts) [Czwajda et al. 2017]. Four events concerning on the sale of new passenger cars of particular brands were placed on platform, in order to examine the trends in their sales. The limitation of the research was questions' introduction on the existing market. At the stage of questions definition, there were considered the following issues: the inability to verify the event by records of sold parts and the subject of current questions. The structure of the question placed on the market was as follows: Will the car brand increase their new cars' market share in Poland?
- The event was introduced to market for a period of 1.5 months. During that period of time, users are expected to make predictions at least once a week for each event. Events on the platform are resolved 10 days after they are closed.

Step 2. Actual monitoring

Prediction markets provide the possibility of ongoing monitoring of the size of the forecasts and their quantity. Visual data presentation from the market, makes it possible to observe the current trend of occurrence of a given event (Figure 4.)

What's more, the forecasting markets also enable the creation of current summaries of all open events on the market, which allows the simultaneous monitoring of the values of forecasts for all open events.



Source: website of the predictive market used in the research

Fig. 4. The level of the forecast of a given event, the number of estimates and forecasts

Step 3. Event's resolution

Forecast's accuracy is determined on the basis of a comparison of the value of the last forecast and its result obtained from the verification of data obtained from reliable sources, e.g. reports, lists, press reports. Owing to the fact that, there are problems with reporting in Polish recycling system, there was impossible to get information about the number of sold, used spare parts in particular time intervals. As the result, it was assumed that the increase in the number of cars of particular brands on the market, will cause demand for spare parts from the disassembly station. Taking into consideration fact, that majority of Polish recycling companies represent small and medium sized enterprises, which operate in the grey marketplace, there were identified problems with access to the sold parts records. Predictive markets give the possibility to use related data to verify the accuracy of the obtained forecasts, which was the major reason for using in the conducted research reports on registration of new passenger cars, in order to resolve the event.

Step 4. Determining the accuracy of forecasts based on historical data

The market archive of platform currently consists of more than 270 settled events connected to various issues concerning new technologies with their number, the size of the last forecast and the obtained result. Based on the already settled events, it was possible to estimate the accuracy of the forecasts for directions of new technologies development. An accurate forecast is considered to be the one in which, after the event's settlement, it turned out, that the event occurred in accordance with the predictions of users playing in the prediction market. The event on the prediction market is settled on YES, if the value of the last forecast is above 0.50, if the forecast result is below this value, then the event is defined as such which will not take place [Czwajda et al. 2017].

Relevance of the forecasts made with use of the platform is as follows. The Table 3 presents the accuracy of forecasts, expressed as a percentage, depending on the three ranges of the quantities of forecasts for a given events. The accuracy of predictions is determined for resolved events analyzed on the platform. A total of 277 settled events from this platform were analyzed. According to the content of Table 3, the accuracy increases while the quantity of forecasts increases, which corresponds to the idea of the wisdom of the crowds. In the case of the analysis of the accuracy of forecasts concerning the directions of new technologies development, the verification of forecasts is mainly based on press reports and published articles. It is because of the fact that data, on which forecasts are made, are characterized by limited access. Therefore, it was assumed that the accuracy of the forecasts achieved at the level of 74.3% could be considered as a good result (the value of 72.6% refers to the

percentage of accuracy without considering the division into the range of small, medium and large forecasts). The authors of the paper, based on the analysis of events' relevance resolved within the prediction market, stated that with the ease of access to data, the accuracy of forecasts is increasing. Owing to this reason, the prediction markets method can be the subject of research, analysis and application in the aspects considered in this paper.

Table 4. Accuracies of forecasts depending on the quantity of forecasts of occurrence of a given event

Quantity of predictions for the event	Accuracy of forecast [%]
1-75 (small)	66.7
75-200 (medium)	69.1
> 200 (large)	74.3

Source: own work

Step 5. Setting sales trends for particular car brands

Predictive markets provide the opportunity to simultaneously evaluate the best-selling brands/car models, develop new trends and technologies in the automotive industry, such as electric and autonomous cars.

There have been introduced few events on the market, investigating the sales trends of currently best-selling car brands. The purpose of this action was to anticipate the demand for spare parts from these car brands. It resulted from the assumptions made by authors of the paper, that the greater the share of cars of a given brand on the market, the greater the need for spare parts of that brand.

Taking into account the fact that the Polish fleet of passenger vehicles is quite numerous, it was found that the greater the number of vehicles on the roads is accompanied by a higher risk of collisions and accidents. As a result, it was stated that there will be provided greater input stream for processes carried out at disassembling facility. In authors opinion, adopted approach convince of the rightness of questions put on the platform.

Step 6. Determination of the number of stored cars / parts at dismantling stations

After forecasts' accuracy establishment from the selected research area, it is possible to undertake activities aimed at the current assessment of inventory, demand monitoring and inventory level updating with the specific frequency e.g. every two weeks.

Predictive markets with unlimited access to cyclic data, e.g. records / reports on the sale of used spare parts, can be used, among others to update the level of stored inventory depending on the size of the obtained forecast, however, it requires further research.

Activities included into this step are particularly important for the examined enterprises, what results from the limited warehouse space. It is noteworthy that, according to the law, parts should be stored in a roofed building, however, due to space constraints, it is not respected requirement (on the basis of the Directive 2000/53/EC). This results in operating costs climb by the environmental penalties.

To sum up presented procedure, following six steps described in details in this Subsection, there was introduced the application of predictive markets in demand forecasting for parts in disassembling business. Consequently, the RQ3 and RQ4 were answered contemporaneously.

CONCLUSIONS

In authors opinion, predictive platform have many advantages, what justifies their use in the conducted research. There were indicated the following advantages of predictive platform use:

- the prediction platform accurately predicted the results of 3 out of 4 events regarding car sales;
- current market situation consideration, what is an advantage of predictive platform in comparison to mathematical models, that are based on fixed conditions. It should be noticed, that the demand on used spare parts

is variable, what convinces of the superiority of the proposed solution in relation to mathematical models;
- possibility of use indirect data, which require appropriate establishment and construction of a questions on the market;
- possibilities of research on various aspects of disassembling company's activity. It is possible to introduce a lot of questions on the platform, related to one specified area or various business activities, including trends and technologies development in the automotive industry. As the result, it allows to analyse recycling company in Poland from different problem areas, in order to improve realized processes. While there are no technical limits to the number of questions, which can be asked on a prediction market simultaneously, market administrator must customize the number of questions to the number of current market participants, so that the number is neither too small (which makes the market not interesting), neither too large (which makes the market overwhelming);
- operating on the principle of the crowds' wisdom, allows to use the implicit knowledge of platform users and to carry out the gradation of obtained data;
- design on the principle of gamification, makes it possible to create mechanisms that motivate users to play and share knowledge;
- possibility of use the implicit knowledge of employees by employers and to shape their knowledge sharing attitude;
- use the knowledge of experts which are the direct stakeholders of recycling companies, including customers and suppliers, as well as employees or station owners, activating them and people indirectly associated with the recycling industry, such as car users, motoring enthusiasts, people associated to the automotive industry: bloggers, researchers, etc.

Considering specific factors of disassembling business, authors selected predictive market as appropriate tool for demand for reusable parts forecasting.

Taking into account the significance of the disassembling facility, in the context of the company's activities, there was identified a need to support the decision-making process related to forecasting the demand for spare parts. It was stated, that uncertainty and problems with reliable data are premises for predictive markets use in the vehicles recycling sector.

Authors are aware of predictive markets limitation including the originality of recommended tool. However, use of internal and external experts becomes an opportunity to better utilize people's knowledge, which has been already the base for demand forecasting in the disassembling business.

The main challenge in introducing predictive markets for use is the cost of analysis, the requirement for IT support and the introduction and motivation of participants to play on the platform.

Authors' future direction of the research include: use of predictive markets to monitor the level of spare parts stocks, assessment of the level of risk occurring in various areas of the disassembly station's operation.

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WYKORZYSTANIE RYNKÓW PREDYKCYJNYCH JAKO NARZĘDZIA WSPIERAJĄCEGO PODEJMOWANIE DECYZJI W SEKTORZE RECYKLINGU SAMOCHODÓW

STRESZCZENIE. **Wstęp:** Kluczowym ogniwem w systemie recyklingu samochodów są stacje demontażu, zarządzające przepływami odpadów oraz części zamiennych. Przedsiębiorstwa te w swojej działalności skoncentrowane są na strumieniu części zamiennych jako że jest on najbardziej wartościowy, mając na uwadze możliwości sprzedaży (wartość ekonomiczna) jak również oszczędzanie zasobów naturalnych (wartość ekologiczna). Zważywszy na wartość przepływu części zamiennych, zidentyfikowano problem związany z prognozowaniem zapotrzebowania, co związane jest z charakterem prowadzonej działalności. Biorąc pod uwagę fakt, że strumień wejściowy samochodów przetwarzanych w przedsiębiorstwie, jest poza jego kontrolą, podjęto próbę wspierania prognozowania zapotrzebowania na części (strumień wyjściowy) za pomocą wykorzystania rynków predykcyjnych.
Metody: Na podstawie wcześniej przeprowadzonych badań, zidentyfikowano problem związany z prognozowaniem w stacji demontażu pojazdów. Wykorzystano metodę analizy i krytyki piśmiennictwa w celu zbadania istniejących opracowań w zakresie metod prognozowania. Mając na uwadze wyniki badania literatury, wykorzystano metodę rynków predykcyjnych, którą wykorzystano w wybranym obszarze badawczym.
Wyniki: W pracy przedstawiono ogólną procedurę dotyczącą wykorzystania i wdrożenia rynków predykcyjnych w procesie wspierania podejmowania decyzji w stacji demontażu pojazdów, w obszarze prognozowania.
Wnioski: Rynki predykcyjne, opierające się na idei crowdsourcingu, wykorzystują tzw. „mądrość tłumu", wspierając zróżnicowane obszary działalności biznesowej, w tym również branżę motoryzacyjną. Publikacja może być traktowana jako przewodnik w zakresie użycia rynków predykcyjnych w specyficznym obszarze problemowym, w tym również tak skomplikowanym jak prognozowanie zapotrzebowania na części zamienne w stacji demontażu pojazdów.

Słowa kluczowe: rynki predykcyjne, stacja demontażu pojazdów, prognozowanie, części zamienne

Liliana Czwajda
Centre for Industrial Applications of Mathematics and Systems Engineering,
Polish Academy of Sciences, ul. Śniadeckich 8, Warsaw, **Poland**
e-mail: liliana.czwajda@gmail.com

Monika Kosacka-Olejnik, https://orcid.org/0000-0001-6950-2728
Faculty of Engineering Management, Poznan University of Technology,
Strzelecka 11, Poznan, **Poland**
e-mail: monika.kosacka@put.poznan.pl

Izabela Kudelska, https://orcid.org/0000-0002-8717-4315
Faculty of Engineering Management, Poznan University of Technology,
Strzelecka 11, Poznan, **Poland**
e-mail: izabela.kudelskaa@put.poznan.pl

Mariusz Kostrzewski
Faculty of Transport, Division of Construction Fundamentals of Transport Equipment,
Warsaw University of Technology, Koszykowa 75, Warszawa, **Poland**
e-mail: markos@wt.pw.edu.pl

Kanchana Sethanan, https://orcid.org/0000-0002-3340-2538
Faculty of Engineering, Khonkean University,
Khon Kaen 40000, **Thailand**
e-mail: ksethanan@gmail.com

Rapeepan Pitakaso, https://orcid.org/0000-0002-5896-4895
Faculty of Engineering Ubonratchathani University,
Ubon Ratchathani 34190, **Thailand**
e-mail rapeepan.p@ubu.ac.th