PREDICTION MARKETS AS A DECISION SUPPORT TOOL IN DISASSEMBLING COMPANIES

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Abstract
Disassembling companies are key participants in recycling networks which manage flows of waste and spare parts. However, due to the large number of dismantled parts and limited storage area, corresponding to the law requirements, it is necessary to anticipate the demand for the most sold parts. The high importance level of spare parts flow is a consequence of high economic potential as well as ecologic. Used spare parts are main source of revenues for disassembling companies, they are wanted by customers, and what is the most relevant – the utilization of used spare parts is the best scenario for products, which achieved end – of – life stage (vehicle).
Disassembling companies mostly represents small and medium sized companies, what is related with low level of computerization, at each area of business activity, including recording parts selling and demand forecasting. In order to support decisions made at this area, it was prepared a concept of a tool based on the research method of predictive markets to anticipate the demand for used parts in dismantling facility. Predictive markets are based on the idea of crowdsourcing, using collective crowd intelligence to predict for example introduction of new medicines on the market, the directions of development of new technologies or competition activities. In the paper it was presented original approach to the demand forecasting in specific business which core flow is a reverse flow of waste.

Keywords:
Predictive markets, disassembling facility, demand forecasting, spare parts.

1 INTRODUCTION
There is an increasing interest in the reuse and recovery of products and materials, resulted from the insufficiency of natural resources and raw materials, environmental issues and law requirements about end-of-life products, particularly vehicles. The automotive industry is one of the top industries worldwide, affecting Economy, People and Planet (3P). Only in the EU, there were roughly 220 millions cars in 2015, while almost 10% of them were Polish (20.72 mln) [1]. Growing production and sales of the automotive industry is increasing the number of End-of Life Vehicles (hereafter: ELV) [2], what can be observed in Poland characterized by fast-growing and fats-aging vehicle fleet. In 2015 around 80% of vehicle fleet in Poland was above 10 years old, more than 40% of all vehicles were above 20 years old [3]. In the result, Polish car is on average 17.2 years old [4], while car in the EU was 9.7 years old [5]. Moreover, average age of ELV, which is recycled is 18.8 years [6]. To sum up, it was stated, that there is high potential for vehicles recycling in Poland, particularly for disassembling facility (hereafter: DF) business. ELVs are hazardous waste, thus they are potential Environmental pollutant, although they are also source of recyclable materials. Everything depends on ELVs treatment, what should be realized in approved companies – a. ELVs are the input and waste are the output of processes[1] realized by DF with the use of limited resources (people, machines and tools, money), under constant monitoring by government (Fig. 1).

According to Fig.1 waste may be managed in different ways, including few scenarios from reuse till landfill. Assuming the "waste recovery hierarchy" proposed by Gerrard and Kandikar, waste scenario should be preferable in terms of energy saving and environmental impact [8], what is another confirmation of the critical role of DF. Excellence of the reuse scenario is the result not only of the ecologic benefits but also economic. In accordance to previous research, authors claimed that more than 60% of revenues of DFs is created by selling used spare parts. 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. If DF offers parts on which there is a demand, it has got a competitive advantage and better profit. DF is disassembling various models of vehicles, at different age. Each vehicle consists of hundreds parts, which may be reused or recycled. Although DF influence on obtained ELVs is marginal, DF is making decisions on parts which are preferable for reuse, which require to be stored. Decisions made on that, what will be warehoused
are influenced by limited space and Employee's knowledge. Workers are deciding what should be stored on the basis of their own experience as well as technical efficiency criterion (therefore, it is important to ensure safety and structural stability for such a construction of warehouse rack or shelves as it is given in Kostrewski M., 2017. Securing of safety by monitoring of technical parameters in warehouse racks, in high-bay warehouses and high storage warehouses [9]), and law requirements. However, there is lack of any support. What is more information about market demand are not used or are used marginally.

Considering the reuse strategy as a most valuable scenario, authors assumed that the basic problem related with decision-making process at operational level is lack of demand forecasting on reusable parts. In order to better present the significance of that issue, there was determined impacts analysis for various aspects of DF activities in the Table 1.

Table 1. Potential impact of decisions made on demand forecasting of used spare parts.

<table>
<thead>
<tr>
<th>Affected area</th>
<th>Stakeholder</th>
<th>Reduction (-) / growth (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort at the workplace</td>
<td>Employee</td>
<td>+</td>
</tr>
<tr>
<td>Competitiveness of DF</td>
<td>Competitor, Government, DF</td>
<td>+</td>
</tr>
<tr>
<td>Cost of business activity</td>
<td>Customer, DF, Competitor</td>
<td>-</td>
</tr>
<tr>
<td>Customer Service Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warehousing area</td>
<td>DF, Competitor</td>
<td>-</td>
</tr>
<tr>
<td>Sustainability assessment</td>
<td>Local community, Customer, Government</td>
<td>+</td>
</tr>
</tbody>
</table>

In addition to data in Table 1, it was stated that demand forecasting of used parts is related to many positive effects, not only economic but also social and ecologic, thus in the paper there was proposed use of virtual prediction markets to support decisions related to demand forecasting.

The paper is organized as follows. Section 2 describes demand forecasting methods in theory and in practice, on the basis of Polish DF. Section 3 highlights basic information about virtual prediction markets. Section 4 guidelines for virtual prediction markets application in DF. In the conclusion there were described limitations as well as benefits from use of predictive markets. Moreover authors have presented future research directions.

2 DEMAND FORECASTING IN DISSASSEMBLING COMPANY

2.1 Demand forecasting – theoretical background

Demand forecasting plays a crucial role in the operations of each participant of modern supply chains because it supports decisions made at various level, including operational, tactical and strategic level e.g. capacity planning [10], resource planning [11], advertising and promotional planning [12], etc.

The knowledge about future demand significantly improves indicators in all areas of logistics activity, however it requires detailed data and their analysis in the realities of modern enterprise, what causes problems. Properly-adopted forecasts allow for adequate management of the inventory and storage space, as well as optimal management of company resources and supply matching, eliminating supply gaps and satisfying customers orders.

Forecasting is future prediction on the basis of premises of different nature, particularly historical data. The basis for forecasting are methods based on statistics and econometrics. On the other hand, the forecasting definition, firstly specifies the date of the prediction, determining it as conclusion of unknown occurrences based on known occurrences [13].

Authors have adopted in the paper approach that, the essence of the forecasting are conclusions integrated into the analysis of occurrences, phenomena and facts that appeared in the near past. While the forecasting issue is related to the demand on products, definition of the demand for products is a prerequisite condition for building a sales plan, next production schedule which stimulates material demand.

Generally, as shown in Table 1, forecasting methods can be divided into two main categories – qualitative and quantitative [14].

Table 2. Forecasting methods [15].

<table>
<thead>
<tr>
<th>Qualitative methods</th>
<th>Quantitative methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judgment (e.g. delphi method)</td>
<td>Moving average, weighted moving average</td>
</tr>
<tr>
<td>Historical analogy</td>
<td>Exponential smoothing</td>
</tr>
<tr>
<td>Focus group</td>
<td>Trend analysis</td>
</tr>
<tr>
<td>Market research</td>
<td>Decomposition</td>
</tr>
<tr>
<td>Markovian</td>
<td>Advanced Time series</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Box–Jenkins (ARIMA)</td>
</tr>
</tbody>
</table>

The qualitative methods are used typically when there is little or no data for mathematically models, although they offer often high-class information about future demand [16]. There are used in qualitative methods, information from experts e.g.: in the delphi method forecast is result of management's opinions, in the historical analogy the basis are information from experts with the same experience in the past. Diffusion models are used to predict the fate of new products, while Markovian models are used to predict consumers and buyers' behaviour. The basic disadvantage of the qualitative techniques is subjectivism, however
simplicity, clarity and low-cost, speak in favour of those methods [15]. The second group of methods are are the quantitative, which can be divided into time series methods for a short time period and causal methods, used to forecast medium and long time period demand. Generally, there are used historical data. In the case of time series techniques, there are used only time series data to build forecasting models, including the following methods: the Moving Average (MA), the Weighted Moving Average (WMA), Exponential Smoothing (ES), Single Exponential Smoothing (SES), and the Box–Jenkins method (e.g. ARIMA) [15]. In accordance to casual methods, there is used set of explanatory variables, including time series components, which are perceived as affecting the predicted value [15]. To sum up, authors claim that it is difficult task to choose well-fitted forecast method and it depends on various factors, including: • current business situation, • the cost of creating the forecasts, measured in time and money, • accuracy of particular forecasting methods.

Considering, warehouse management area in typical manufacturing company, one of the most relevant issues is determining the type and number of warehoused spare parts. Identification of type of parts in stock should be based on economic result, meanwhile in the case of the number of spare parts, the attention should be paid to the planning the procurement process. Authors assumes that, in the case of new spare parts, there can be used mathematical forecasting models for predicting the future demand, although planning the demand for used parts is more difficult, what was contribution for the next subsection, where there is described demand forecasting for used spare parts in disassembling company.

2.2 Demand forecasting in disassembling company – state of art

Considering the importance of the DF and demand forecasting related to its activity presented in Section 1, authors described the process of demand forecasting on used spare parts in chosen Polish DF, which is processing about 1200 ELVs per year. In the result, it is one of the top companies in the sector.

The focus of the paper lies on parts which may be reused, which are not excluded according to the law requirements (safety factor). Authors claimed that, requirements for procurement and warehousing of used spare parts from ELVs, they should be considered in relation to the product - vehicle as well as new parts. In the consequence there were specified particular features of used spare parts turnover, what has a significant impact on the requirements and management structure of demand forecasting on used parts, including:

• negative customer’s feeling which is caused by a need of purchasing spare part (e.g. failure of primary part),
• limited time of planning the demand for spare parts,
• dependency on demand for spare parts with the total sale of new vehicle and original new, spare parts as well as on maintenance or service, and on the durability of the used parts,
• diversification of customers purchasing used spare parts (not only final customers, but e.g. car mechanic) (what makes forecasting as required process not only in DF.

The primary principle in DF is that part ordered by the customer, should be available within the required time. Parts are available from parts stock (in the warehouse) or from ELVs which (so called ‘temporary stock’), where parts are removed if order occurs. If customer orders few parts or one part which requires disassembling the greater part of the vehicle, there is made decision about the total disassembling (part is not available from parts stock). Particular stages of the distribution reusable parts in DF were presented in the Fig. 2:

According to Fig. 2, the customers in the distribution channel of used parts are: shops, workshops, and private vehicle’s owners, which are submitting a request on selected part/parts. There are used two business models of parts sale, including direct sale from DF and the use of Internet distribution channel. If ordered part is not available, customer may be informed about the part’s availability next days. 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 a stored ELVs. 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 and used methods, tools is determined by:

• the customers’ needs,
• the technical condition of the part,
• the knowledge of the Employees from the Sales/Advertisement department about market demand, on the basis of experience.

Mostly, there are no procedures which would control the performed tasks, what results in making some decisions by random worker. Moreover, the customer has the ability to dismantle the parts themselves or DF’s worker makes that. Authors assumed, that all parts disassembled from ELVs in DF may be divided into one of two categories: standard parts and unique elements, presented in the Table 3.

<table>
<thead>
<tr>
<th>Table 3. Parts disassembled from ELV.</th>
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</thead>
<tbody>
<tr>
<td><strong>Unique elements</strong></td>
</tr>
<tr>
<td>Part disassembled due to customer order</td>
</tr>
<tr>
<td>Forecast based on employee knowledge and experience on market demand</td>
</tr>
<tr>
<td>Redistribution channel</td>
</tr>
<tr>
<td>Warehousing</td>
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</table>

The unique elements category are parts which were not on standard equipment of vehicle produced serially. They are distinguished by different color/material/construction. Because the value of this part is high, they have special place in the warehouse, available only for sales manager,
because other workers, who do not know trends in automotive industry could sell the part under the value with the loss for the DF. In the result, the knowledge about market demand on that category of parts is valuable, however there is no catalogue of them. In the result the identification and subsequent dismantling of unique items, largely depends on the perception of the worker and his knowledge about the automotive industry. Moreover sales manager has the knowledge about potential market, having a direct contact with customers and organizing the supply. Standard parts are available at online auctions via Internet, as well directly in DF from the stock.

To sum up, there are two kinds of input data for disassembling process: customer orders as the first and forecasts, based entirely on the experience and knowledge of the Employee, as the second one. Authors assumed that, in the case of the second one, the risk of financial loss increases. Storage costs, occupied storage space, frozen capital are few factors that can contribute to optimizing the performance of the DF and the resources that are required to get them [17].

Authors claimed, that forecasts are not a goal in and of itself, but they may be a tool supporting the planning and management of individual DF’s areas. In the result customers needs may be better fulfilled and reuse scenario may be better realized.

3 PREDICTION MARKETS AS A DECISION SUPPORT TOOL
3.1 Origin of prediction markets
Prediction markets are based on a crowdsourcing research methodology, the essence of which is the use of collective intelligence, which means "the ability of a group of people to improve their knowledge, competencies and skills through collaboration, debate and sometimes competition" [18].

Prediction markets are using crowd's wisdom by aggregating distributed knowledge. The first prediction market (known in its current form) was founded in 1988 at the University of Iowa and was named Iowa Political Stock Market. It was used to predict the results of the presidential election. Since then, prediction markets have been used in order to predict the movie’s score or the size of economic indicators. In the business practice, they are used as: a decision support tool for monitoring the current status of projects, their progress and expected end dates, or as tool for forecasting sales and component purchasing costs, and as a management support (e.g. investment risk) in new technologies.

HP as a global company, is using predictive markets e.g. in order to forecast monthly printer sales and forecast purchase costs of DRAM memory. Market players (company employees) receive a startup amount, and then they are making betting on the printer’s sales interval, which will be reached within three months. In the result, it was confirmed that forecast made with the use of predictive markets were more accurate than the official management forecasts in 75% of cases [19].

In the case of the pharmaceutical company - Eli Lilly, predictive markets were used for evaluation the success of pharmaceutical projects launching new drugs. In 2003 those forecasting tool was also used by Microsoft in order to evaluate the timing of the project, and since 2006 the scope of predictive markets was expanded to software error forecasting [20].

In Poland, in 2014, there was launched by the Agency for Industrial Development SA and the Center for Applied Mathematics and Systems Engineering PAN, the prediction market named Logical Extraction Capability NANO - L.E.M. Nano, which has been used to predict the development of modern technologies with particular emphasis on graphene.

3.2 Implementation
On the predictive markets, the users of the platform try to predict the probability of certain events, namely predictive event. Authors claimed, that the predictive market gives the opportunity of better evaluation than it becomes from surveys. It is a result of asking participants not only about perceiving the reality, but also about the estimation of the probability. Considering above information, it was stated, that this approach requires a rational look at the facts (polls, discussions, speeches, scandals and crises) and gives the opportunity to evaluate the event, that influences the outcome of the event on the market [18].

In order to apply the idea of crowdsourcing on the predictive markets there should be made the following steps:

- identification of the target audience, to which the event will be directed,
- identification of the representative group that will provide objective results,
- creation a question on the predictive market, that will address a particular event,
- determination the time period, in which the event will be placed on the predictive market and the date of its outcome,
- specification the verification sources of an event placed on the predictive market, e.g. based on a specific report, information from specific sources, press releases,
- making some conclusions about the probability of occurrence of a given event, on the basis of all participants.

4 PREDICTION MARKETS APPLICATION IN DISSASSEMBLING FACILITY
In the paper authors were focused on presentation of the concept of the predictive market use, in DF, in order to support decisions at the operational level, related to the issue of used parts dedicated for redistribution. According to predictive markets characteristic, there will be examined dispersed knowledge of the DF staff in order to investigate the demand for used parts/vehicles.

As it was mentioned in the previous sections, warehousing excessive stock generates a lot of costs, which decrease competitiveness of DF, where warehousing area is limited. Authors claimed, that diversity of brands and models of vehicles which are dedicated for utilization has got the greatest impact on DF activity. In the company under study there is on average about 100 – 200 different vehicles (mentioned before as ‘temporary warehouse’) and about 40 types of different parts which may be obtained from one vehicle. Considering that, authors have distinguished a group of 27 vehicles, on which there is the highest demand on their parts in order to estimate the volume of the monthly demand on them.

Taking into account information about predictive markets from Section 3, the following criteria for the predictive market were adopted:

1. The representative group will be about 15-20 people. The target group will be created by DF Employees, particularly workers who directly disassemble vehicles and sell reusable parts. Those people have the
knowledge about market demand on particular parts (treated as experts). However, DFs are mostly small and medium sized companies, what may complicate building the representative group among DF’s Employees, authors claimed that, there should be included other experts for demand estimation on used parts/vehicles (e.g. by owners of car workshops’, bloggers from automotive sector, etc.)

2. The 27 questions about demand for the vehicles for which the demand is greatest, will be put on the predictive market. The structure of the question is:

Will the demand for parts from the x-brand of the vehicle, z-type of part, increase?

3. Events will be put on predictive markets for a period of three months. In that time, experts will make forecasts at least once a month for each event. The deadline for resolving the event on the platform will be one week after the event will be closed.

4. Verification of the even put on the platform will be based on the records of sales of parts from specific brands and model of vehicles.

5. Based on the obtained results, the number of parts/vehicles stored in the DF, will be determined according to the brand and model of the vehicle, from which the parts will be sold.

In the result authors have prepared the visualization of the proposed tool, supporting estimations on demand forecasts on reusable parts disassembled from ELV’s (Fig. 3).

To sum up, authors have presented the possibility of use the predictive market in DF in order to forecast demand on reusable parts. The next stage of research is related to introduction presented concept into company under study.

5 CONCLUSIONS

Predictive markets use crowdsourcing idea, providing a wide range of opportunities for acquiring and aggregating distributed knowledge of their community, including Employees.

In many cases, the accuracy of the forecast obtained with this tool is much better than, e.g. surveys. Moreover, predictive markets also have the potential to achieve a better result at a lower cost than other analytical solutions. Consequently there may be reduced R & D department, which is expensive one.

Considering the significance of reuse scenario for parts disassembled from ELV’s in DF, authors have proposed original approach for demand forecasting for reusable parts, with the use of virtual predictive markets. Authors perceive limitations related to the proposed tool, including the cost of analysis as well as requirement of IT support, however potential result may be adequate demand forecast for redistributed parts. Moreover introducing that tool for all companies in recycling sector could be support from Government as an investment in recycling sector which has got a high potential in Poland, as it was mentioned in Introduction.

Another challenge is development of good motivation system for participants of the platform. Firstly, Employees should be trained, and secondly well motivated for continuous games on prediction market, e.g. by material awards, including additional salary if they have the best matches on the platform. There may be some problems related to high the resistance level of workers in Poland, resulting from fear of something new.
Although there are many challenges related to predictive markets use in DF, they offer a wide range of possibilities to use them in the recycling area, e.g. they may be used to estimate the probability of supplies of ELV's to the DF, to coordinate those two streams (input and output) as well as to get information from Employees, when sell of parts is not recorded, what is characteristic for SME's. However, it requires finding another source of events' verification on the platform.

The presented concept is an original approach, which is considered to be apply in a company under study. Future research direction include research on results of introduction predictive markets into recycling sector.

6 REFERENCES


