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ICT solutions supporting the customer services in the process of collecting secondary materials

Rozwiązania informatyczne wspomagające obsługę klienta w procesach zbiórki surowców wtórnych

Abstract. The limited availability of natural raw materials leads to a search for solutions facilitating their acquisition from already manufactured goods, which at the end of their life cycle become a source of secondary raw materials. To ensure the availability of secondary raw materials, it is necessary to organize logistics processes in such a way as to ensure the synchronisation of material and information flows. An important role for the efficiency of the logistics system of secondary raw materials is the organisation of the subsystem of their collection, including setting collection dates and delivery of appropriate logistic units to customers. The article presents the results of a survey on a group of individual customers assessing their customer satisfaction with the organisation of secondary raw material collection. The CSI index was used to assess satisfaction. This evaluation became the basis for identifying the information gap in customer service. A conceptual solution to improve the information flow between operators and customers in the form of a mobile application was proposed as a solution to the disruption in this area.

Key words: secondary materials, circular economy, reverse logistic, ICT solutions

Synopsis. Ograniczona dostępność surowców naturalnych powoduje, że poszukuje się rozwiązań ułatwiających ich pozyskanie z już wyprodukowanych dóbr, które po zakończeniu cyklu życia stają się źródłem surowców wtórnych. Dla zapewnienia dostępności surowców wtórnych konieczna jest taka organizacja procesów logistycznych, by zapewnić synchronizację przepływów materiałowych i informacyjnych. Dużą rolę dla sprawności systemu logistycznego surowców wtórnych odgrywa organizacja podsystemu ich zbiórki, w tym ustalanie terminów zbiórki i dostarczanie odpowiednich jednostek logistycznych do klientów. W artykule zaprezentowano wyniki badania ankietowego na grupie indywidualnych klientów oceniające ich satysfakcję z organizacji zbiórki surowców wtórnych. Do oceny satysfakcji wykorzystano wskaźnik CSI. Ocena ta stała się podstawą do identyfikacji luki informacyjnej w zakresie obsługi klienta. Jako propozycję rozwiązania zakłóceń w tym zakresie

zaproponowano koncepcyjne rozwiązania usprawniające przepływ informacji pomiędzy operatorami a klientami w postaci aplikacji mobilnej.

Słowa kluczowe: surowce wtórne, gospodarka o obiegu zamkniętym, logistyka zwrotna, rozwiązania ICT

Introduction

Management of waste and recyclable materials is an important aspect for companies in supply chains. The amount of waste and recyclable materials is constantly growing, which on the one hand makes it a problem, whereas on the other hand it provides opportunities for the development of innovative solutions, in both the technological and organizational sphere. Waste and recyclable materials that end up in landfills are a real threat to the environment and have a direct and indirect impact on living conditions, as well as on health and functioning of the society and economy. The issues related to the management of waste and secondary materials are becoming important, primarily from the point of view of European regulations contained, inter alia, in the Green Deal [European Commission 2019] and of increasing pressure to find alternative sources of materials and energy. Efficiency of logistic processes in the management of waste and recyclable materials is becoming crucial for the fulfilment of environmental and economic goals not only for companies but also for regions and whole countries [Szołtysek 2009]. In order to achieve these goals, it is necessary to provide access to and exchange information between various entities, which is only possible with the use of appropriate IT solutions. IT solutions in logistic chains, where waste and recyclable materials are the subject of the flow, serve mainly to control and optimise the flow going through all the links [Daugherty et al. 2005].

Efficient information flow is crucial not only for meeting the environmental requirements but also for gaining competitive advantage, and often also for effective functioning within the market. The specificity of the secondary material market, particularly the sources to obtain these materials, makes it a challenge to develop dedicated IT solutions [Morgan et al. 2016].

The aim of the article is to present an ICT solution supporting the process of servicing customers who deliver secondary materials. The research used source data coming from a survey conducted among the customers of recycling companies, which then allowed to determine the CSI index. The survey was conducted among 200 randomly selected entities from the provinces of Silesia and Lesser Poland (Małopolska) which used the services of secondary material collection in the period between January and June 2020. The results of the survey were used to develop a concept of an IT tool to support the processes of collecting recyclable materials.

Secondary material management system

The term ‘secondary material’ has not been defined in the Polish and European legislation. This term usually refers to production waste or used products that can be reworked or reused after being recycled to recover valuable materials [Cepriá and Hiniesto 2015]. Hence, terms such as post-consumer waste, production waste (post-production, indus-

trial), post-depreciation waste (post-depreciation scrap), mining waste, electronic scrap, etc., are sometimes used interchangeably. Secondary materials are seen as value recovered from waste [Rogers and Tibben-Lembke 1999]. According to the provisions of Directive 2008/98/EC and its Polish equivalent [Ustawa z dnia 14 grudnia 2012 r.], waste is defined as substances or objects which the holder discards, intends or is required to discard. Production of waste is related to various human activities and thus waste has various form and composition. Due to a wide variety of types, waste can be divided into several groups [Rozporządzenie Ministra Klimatu z dnia 2 stycznia 2020 r.]. This division can be made according to: physicochemical composition, origin, level of danger to the environment (including humans), state of matter, toxicity and potential of further processing. To organize the classification, specific legal regulations have been adopted, which includes a waste catalogue and systematizes waste according to the following criteria: origin, properties of hazardous waste and potential threat to the environment. In practice, the waste catalogue makes it possible to distinguish 20 groups depending on its origin, including one group which comprises municipal waste [Rozporządzenie Ministra Klimatu z dnia 2 stycznia 2020 r.]. Vast majority of waste retains some characteristics and/or properties that give them the potential of being re-used. This approach creates environmental opportunities: reduction of the environmental impact that waste causes, as well as economic opportunities due to savings on acquisition of resources and materials [Mai et al. 2012]. Resources and materials that are obtained from waste are called secondary materials. Those are a type of waste that can be reused or processed for production and consumption. In strategic policy documents such as the National Waste Prevention Programme [Krajowy program zapobiegania powstawaniu odpadów z dnia 26 czerwca 2014 r.], the term 'secondary material' is generally not used. Instead, the term 'waste for selected groups of industries' is used, including, among others: mining waste, waste from the metal processing and chemical industries, as well as energy production waste (waste from the iron and steel production and, most of all, from the energy production industry). Hazardous waste from economic activities is also distinguished, including used batteries and accumulators, used electronic and electric equipment and decommissioned vehicles [Bendkowski and Wengierek 2004]. Whereas, a different classification is given in the National Waste Management Plan 2022 [Uchwała nr 88 Rady Ministrów z dn. 1 lipca 2016 r.].

The term "secondary materials" appeared in the draft document of the Ministry of Development entitled "Secondary materials for the industry. Action plan for securing the supply of non-energy mineral materials" [Ministerstwo Rozwoju 2017] but without providing a definition. At this point it is also necessary to refer to the classification given by the Statistics Poland where secondary materials are divided into natural secondary materials, processed secondary materials and waste materials, which are divided into post-production waste (generated during production processes) and used products, i.e. post-consumer waste [GUS 2019]. The latter can be used by another user after appropriate preparation, replacing the primary material. There are also a number of definitions in the available literature that refer to secondary materials and their classification. The multitude of waste classification in law and strategic documents as well as a lack of unified approach to secondary materials makes it difficult to classify and categorize them and to choose dedicated solutions related to the management of their flow throughout the whole reverse logistic chain.

In the context of intensive promotion and development of the circular economy concept in the European Union [European Commission 2018], it is necessary to verify the approach to the problem of waste, with particular emphasis on the notion of secondary materials, legislative and organisational solutions for handling them so as to transform waste management into sustainable management of material flows. In this respect, implementation of the circular economy concept involves, among other things, sorting out definitions and classifications of waste and identifying it as a source of potential secondary materials, ensuring availability and security of their supply and limiting the negative environmental impact by closing material cycles and promoting recycling and wider use of waste [European Commission 2015].

From a logistics point of view, management of secondary materials is a very broad issue, described, among others, by [Szołtysek 2009]: its structure, methods of collecting, used means of transport, treatment procedures, recovery and disposal. There are several processes involved in the waste and secondary material management system (Figure 1).

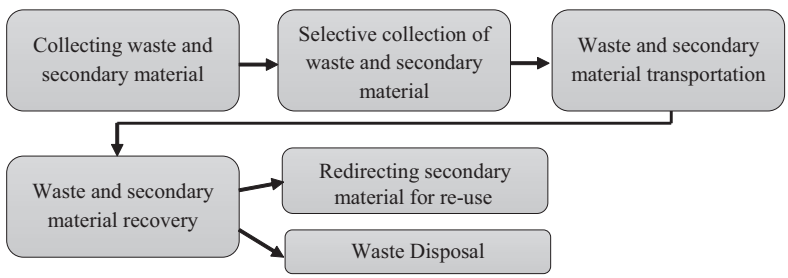

Figure 1. Processes in the logistic system for waste and secondary material
Rysunek 1. Procesy w systemie logistycznym zagospodarowania odpadów i surowców wtórnych
Source: adopted from [Zębek 2018].

The first stage in the management system for secondary materials is collection, which involves placing them in locations and / or containers suitable for that purpose. This also includes on-site storage of secondary materials. The second step is selective collection of secondary materials. There are different solutions for selective collection of secondary materials [Smolnik and Kozerska 2012]:

- containers located in the vicinity of houses, blocks of flats and other buildings – a system based on a selection of locations where containers for selective collection of recyclables will be placed,
- a special, limited area with full equipment - bins and containers in which various types of recyclables are collected,
- 'collection at the source' – collection of recyclables directly from households, which is considered to be the most effective system of selective collection of recyclables,
- regional collection points for secondary materials, which are designed to collect and pre-sort them.

Transport is another process in the management system of secondary materials, which is carried out using a technically advanced vehicle fleet or a pneumatic transport system. The final stages are recovery, sharing and disposal of secondary materials.

Survey of customer satisfaction with secondary material collection services

The secondary material market in Poland is estimated to be worth PLN hundreds of millions or even billions. Its significant resources and untapped potential are the reason why more and more business entities start activities in that area. Development of the secondary material market is fostered by increasing environmental awareness of the society and needs of entrepreneurs that use secondary materials. Legislative and economic aspects are also important. Year after year, the share of selectively collected waste and secondary materials that can be recycled or reused is increasing. According to Statistics Poland data for 2018, about 128.6 million Mg of waste was produced in Poland, of which about 115.3 million Mg was post-production waste and 12.5 million Mg was municipal waste [GUS 2019a]. In the case of municipal waste, a positive development is the increase in the share of selectively collected waste – in 2018, about 28.9% of municipal waste was collected selectively (in 2010 it was only 8.6%).

Intensive development of the waste and secondary material management sector means that new and existing companies are subject to the same rules of competition as companies in the supply chain. Above all, competition is intensifying at the contact stage with customers to ensure better adaptation to customer needs and requirements. In the second half of 2020, a customer satisfaction survey was conducted on the quality of service provided by recyclers. The survey made it possible to develop proposals for innovative customer service solutions for collection of recyclables. The questionnaire included 9 questions, which asked customers about, among other things: the type of recyclables returned to the companies who collect them, the frequency of use of recyclables collection services, the importance of factors affecting the choice of recyclable collection company, the level of satisfaction with the implementation of the collection of recyclables, a comprehensive assessment of the process of recyclable collection. The collected results allowed to calculate a Customer Satisfaction Index (CSI), which is one of the basic tools used to assess customer satisfaction. The index is a measure that allows for integration of logistical customer service elements and the results made it possible to identify areas for improvements in the customer service process. CSI is calculated by means of the satisfaction rates expressed by users, weighted on the basis of the importance rates, according to the following formula:

$$CSI = \sum_{i-1}^{N} \left(c_i \cdot w_{iw} \right)$$

in which:

c_i – the mean of the satisfaction rates expressed by users on the service quality i attribute

w_{iw} – (importance weight) is a weight of the i attribute, calculated on the basis of the importance rates expressed by users.

Specifically, is the ratio between the mean of the importance rates expressed by users on the *i* attribute and the sum of the average importance rates of all the service quality attributes:

$$w_{iw} = \frac{w_i}{\sum_{k=1}^{N} w_i}$$

CSI represents a good measure of overall satisfaction because it summarizes the judgments expressed by users about various service attributes in a single score. The more accurate the selection of the attributes, the more accurate the measure of the overall satisfaction. For this reason, the selected attributes should describe the service aspects exhaustively.

In the survey, respondents identified 4 main types of recyclables that are collected by local waste collection operators (Figure 2). The most frequently collected recyclables are waste paper (30%) and plastics (as much as 40%).

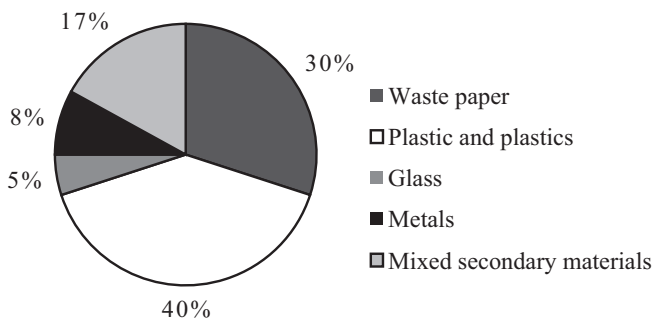

Figure 2. Main types of recyclables that are collected by local waste collection operators
Rysunek 2. Główne rodzaje zbieranych surowców wtórnych przez firmy odbierające odpady
Source: data from survey.

The CSI index was developed on the basis on the results of the questionnaire survey for questions regarding customer satisfaction and the importance of logistical customer service elements for the collection of recyclables from the customer [Wolniak and Skotnicka-Zasadzień 2008]. The mean value of the weights of the selected logistics customer service elements (c_i) and the mean value of customer satisfaction (w_i) were then calculated. A summary of the results is presented in Table 1.

Analysis of the results shows that the values obtained for the indicators are comparable. The lowest value of the satisfaction index is 2.57 and relates to the timeliness of order fulfilment, while the highest value (3.57–3.65) was obtained for the following three parameters: service fulfilment costs, variety of payment methods and complaints. When analysing the significance indicator, the lowest value is 3.03 and it concerns the variety of payment methods. On the other hand, the highest value of the significance indicator relates to the timeliness of service execution and the costs incurred for order execution. The values are 3.92 and 3.83, respectively. The CSI index was then calculated, which is 65%.

Table 1. Calculation of CSI
Tabela 1. Obliczenia wskaźnika CSI

Elements of logistical customer service	w_i	c_i	w_{iw}	CSI	CSI max
Service availability	3.40	3.03	0.095	0.287	0.474
Timeliness of service delivery	3.92	2.57	0.109	0.281	0.546
Comprehensiveness of the service	3.73	2.85	0.104	0.296	0.520
Time of order realization	3.83	3.17	0.107	0.338	0.534
Reliability	3.68	3.20	0.103	0.328	0.513
Competence of employees	3.40	3.37	0.095	0.319	0.474
Communicativeness and involvement of employees	3.60	3.53	0.100	0.354	0.502
Costs of service execution	3.83	3.57	0.107	0.381	0.534
Variety of payment methods	3.03	3.57	0.084	0.301	0.422
Complaints	3.47	3.65	0.097	0.353	0.483

Source: own calculations.

The literature sources quote 60% as a satisfactory value. However, this is a threshold value, which indicates the need to seek and implement new solutions that would improve the level of customer service, especially in the matter of collection of recyclables.

Design of an application to improve the implementation of a secondary material collection service

The results of the conducted customer satisfaction surveys, CSI assessment and conclusions coming from them indicate the need to develop a conceptual solution that would support activities of enterprises collecting recyclable materials in such areas as service availability, comprehensiveness, delivery time and timeliness. Current trends in that matter indicate the need to use solutions based on electronic communication with the customer. The development of a mobile application, which will enable online handling of secondary material collection orders and enable the exchange of necessary information in that matter is a key step in the development and improvement of customer service. Thanks to the application, the customer will more easily and quickly obtain information on service availability, timeliness and delivery time.

The concept of the product (the mobile application) is based on the assumption that it is software that will allow mobile devices to quickly and easily order collection of recyclable materials. In this way, some traditional documents will be eliminated from circulation and access to current information will be provided anytime and anywhere. The designed application would support the following operating systems: IOS, Android, Windows Phone. The mobile application would be designed in such a way as to make it easier for customers to place orders. The first stage of using the software is to download it and provide identification and contact details. The main view (Figure 3) includes such elements as:

– due date – this will mainly concern the choice of date of service and checking the availability of a given term, customers will be able to see which due date is occupied and which is free, therefore allowing them to choose a convenient date;

- execution timeframe – by clicking on this icon, the customers can specify the times at which they would like collection of recyclables to take place, thus saving time while waiting for people responsible for the service;
- recyclables – using this template customers can select the type of recyclable material from the following: recycled paper, plastics, metals, glass and mixed; in addition, the customers can specify the size of the recyclable material, so as to choose an adequate means of transport;
- cost – this icon will allow customers to see the price list for the service, which will be divided up according to the size and type of recyclables purchased;
- monitoring – this window allows customers to monitor how the service order is progressing and whether everything is progressing correctly;
- service evaluation – by opening this window customers will be able to assess the service after it has been rendered by the company and communicate whether they are satisfied with the service or not. The providers will be able to determine which aspects of the service require improvement. Therefore, the company will have an insight into what should be further improved.

Figure 3. Control panel of ICT solution for operator collecting secondary material (own design)
Rysunek 3. Panel kontrolny rozwiązania teleinformatycznego dla operatora zbierającego materiał wtórny (własny projekt)

Source: own elaboration.

The proposal to introduce a mobile application in handling of recyclable materials is primarily intended to improve the processes of logistical customer service. The introduction of timeliness, time and cost modules will allow customers to individualize the service. The introduction of a mobile application to the service providing company brings the following benefits:

- improvement of customer service quality,
- increase in customer satisfaction, thus increasing company revenue,
- streamlining the order placement and fulfilment process,
- saving time for both customers and the company employees, as everything is saved on the platform and employees do not have to enter it manually,
- quicker flow of information between the customer and the company,
- increased usability of this way of ordering,
- customers have access to information on costs, deadlines,
- increased efficiency of the company.

The app can be a way for better communication with a customer in a situation when the customer is offering the secondary raw materials for collection (pick up option). At the same time, the application would fulfill the needs of building ecological awareness of customers and responsibility for the way of waste management.

Summary

In order to reduce the negative impact on the environment and to ensure the availability of materials, more and more emphasis is being placed on solutions related to waste management, especially in relation to secondary materials. The concept of circular economy plays a particularly important role, which indicates the possibility and necessity of a new approach to systems and logistics processes of managing secondary materials (reverse logistics). The conducted literature study indicates a number of legislative and organisational barriers related to secondary material management, the most important ones being those currently focused on definitions. The survey carried out among the customers of companies that collect secondary materials indicates that the biggest disturbances in the process of secondary material collection and collection service implementation occur in the process of their aggregation and collection. Irregularities are mainly related to the timeliness and span of service delivery. Lack of customer satisfaction affects the functioning of the system of secondary material management as a whole, and thus heavily impacts the effectiveness of implementation of circular economy objectives. The article proposes an improvement of logistics customer service processes in the area of secondary material collection by using an Internet communication channel with a dedicated mobile application. The main functionalities developed in the application are a response to the identified disruptions in the customer service process. The application can be one of the elements to improve the efficiency of activities aimed at better use of waste, in particular the transparency of material flows, monitoring and tracking of waste / recyclables.

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