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Model of the circular economy and its application in business practice

Otakar Ungerman[1] **· Jaroslava Dědková**[1]

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Abstract
The circular economy is a philosophy that is clearly beneficial to the environment. The question is what economic result is offered by this philosophy and how to quantify that result. The aim of this paper is to put together a model of the circular economy to determine the economic result of enterprises' involvement in the circular economy. The model has been created and subsequently applied in business practice. The model was applied on the basis of primary research aimed at determining the level of enterprises' involvement in renovation, reuse and recycling, and hard data were acquired from the Czech Statistical Office. The model enabled the quantification of the impact of enterprises' involvement in the circular economy. The results exactly proved that enterprises profit through their involvement in the circular economy. A loss was demonstrated in just one sector and one phase of processing discarded waste. The results demonstrate a positive economic impact in the long term. The main obstacle in the short term is the initial investment in technology and processes for processing discarded material. The main scientific benefit of the paper is the creation of a functional model of the circular economy, which was applied in practice. The results of this work clearly prove the claim that the circular economy has a positive impact on the environment, and also on enterprises' economic prosperity and thus the aggregate economy of the state.

Keywords Circular economy · Life Cycle Assessment · Renovation · Reuse · Recycling

JEL Classification L10 · L19 · M11 · M14 · Q56 · Q57

✉ Otakar Ungerman
otakar.ungerman@tul.cz

Jaroslava Dědková
Jaroslava.dedkova@tul.cz

[1] Department of Marketing, Faculty of Economics, Technical University of Liberec, Liberec, Czech Republic

1 Introduction

The current economic system in advanced economies places great pressure towards sustainable development, one of the cornerstones of which is the circular economy. The circular economy is a philosophy, which creates functional and healthy relationships between nature and human society. The idea of the circular economy is derived from the closed-loop flow of products, materials and manufacturing equipment (Heyes et al. 2018). This means replacing the linear system with a circular system. The linear system is created primarily by the extraction, manufacture, use and disposal of raw materials. The circular system, in its perfect form, would mean the constant circulation of raw materials, products and materials, which, instead of ending up in a landfill, would be reused in manufacturing (Kalmykova et al. 2018). Perfect circulation is so far merely a theoretical possibility, but partial circulation is now used in many fields and is becoming part of many a company's long-term strategy.

In the long term, the consequence of introducing a circular economy is that the extraction of raw materials would be replaced by discarded material. Sustainable design plays an important role in the potential of the circular economy. Enterprises that want to join the circular economy should consider reprocessing potential when developing a product. The circular economy is a very modern concept, as it is able to combine environmental protection with economic profit. As claimed by Geissdoerfer et al. (2018) the involvement of enterprises in the circular economy results in savings on costs. This is due to the high cost of obtaining primary raw materials and the instability of their prices. One benefit of involvement in the circular economy is that it enables companies to present their socially responsible behaviour for marketing purposes. The circular economy also benefits the whole of society, as less extraction of primary resources results in less destruction of the landscape. In general, the circular economy may be described as being a great chance for European and Czech firms. According to the American consulting company McKinsey et al. (2014), the European Union economy could save almost two billion euros per year by 2030 thanks to the circular economy. The European Parliament estimates that up to two million new jobs could be created during the same period of time. The development of the circular economy in the Czech Republic requires a change in thinking and also the realisation that it is not an obstacle to one's own business, but is, in fact, a great opportunity.

The concept of the circular economy is a highly attractive form of long-term business strategy. The current situation with the circular economy in the Czech Republic is not particularly clear. The Czech Statistical Office does not collect precise data on involvement in the circular economy, although it does collect data on costs divided up into fields, which are used in the research. The theme of this article on the circular economy is highly topical and is one of the European Union's priorities. Its latest initiative is the Bioeconomy Action Plan from October 2018, where, in addition to other suggestions, it proposes an investment platform with a budget of 100 million euros. The results of the research take our view of the circular economy to the next level and show how it can be recorded and evaluated. As stated by Vegera et al. (2018), it is very important to identify industrial waste as accounting costs in the integrated stages of the technological cycle in the context of the individual sectors of the manufacturing industry. The topicality of the issue was the main reason for the research carried out by the Department of Marketing and Trade at the Faculty of Economics of the Technical University in Liberec, which resulted in this paper.

Main aim of the paper: To put together a suitable model that could be used to determine the effectiveness of the circular economy in business practice. To apply that model across

the most important fields of the domestic economy. This aim is determined in four research questions:

Research questions:

1. How many enterprises in the Czech Republic are in the circular economy?
2. Do the results differ in the assessment of the quantity of discarded material in the individual fields?
3. What are enterprises' reasons for joining the circular economy?
4. Is it economically beneficial for enterprises to join the circular economy? In what fields?

The paper is divided up into seven chapters. It follows the principle of IMRAD (Introduction, Methods, Results, and Discussion), together with a literary overview chapter, presenting the basic theoretical directions. This is followed by a chapter on methodology, with graphics presenting the conceptual framework of the research as a whole, which is then explained in detail. The results part is divided up into four chapters: creation of the theoretical model, presentation of the primary research, calculation of data for application of the model and verification of the model in practice. All these chapters show the sequence of the research and assessment. The discussion chapter compares the most interesting theoretical findings with the actual results of the research. Everything is then summed up at the end of the paper.

2 Literary overview

The main sources for the theoretical research were worldwide and domestic specialised literature and scientific databases, such as ProQuest, Scopus, WoS and Science Direct. The research clarified basic information and studies that had some link with the main aim of the project. The theoretical work for the paper can be divided up into three parts. The first focused on the current global perception of the circular economy, the second related to the Life Cycle Assessment model, and the third dealt with the level of processing of discarded products in the 3R model.

2.1 Current state of the circular economy

The concept of the circular economy originated back in 1960 (Donough and Braungart 2002), when there was increasing interest in environmental protection and more and more ecologists, economists and especially consumers began to pay attention to this issue. Enterprises started to respond to this situation in the 1970s, by introducing the concept of corporate social responsibility (Farrington et al. 2017). The British Standards Institution (BSI), which published the first standard of the circular economy called BS 8001: 2017, is also involved in the circular economy. The directive is more descriptive when it explains the basic principles of circular economy, but does not deal with monitoring or evaluation (ISO 2019). Development of the knowledge and circular economy at the international level saw a huge surge after 1990. The circular economy primarily originated in the ecological economy and industrial ecology (Lewandowski 2016). The mass rise of globalisation and China opening up to international trade at the turn of the twenty-first century has also resulted in the globalisation of ideas of the circular economy. According to the Chinese author Yu and Shi (2007), in our contemporary global society with its increased level of integration

environmental protection is an important aspect of enterprises' activities all over the world. Its effects can be seen not only in the economy and finance, but also in consumerism. In modern-day China, the circular economy is supported as a national political goal, while in the European Union, it is an instrument of environmental policy (Ghisellini et al. 2016). The circular economy is characterised by its closed-loop flow of material and energy, taking account of natural and human resources, science and technology (Camilleri 2018). Velenturf and Purnell (2017) claim that the transition to the circular economy requires scientific and technological progress, including the development of low-energy technology for resource recovery. Green economy principles can be achieved through energy-efficient equipment, the modernisation of infrastructure and constant checks and monitoring of energy consumption (Hole and Hole 2018). The priority is to make savings and efficient use of limited natural resources, streamline product manufacturing and reduce the amount of waste generated, followed by limiting sources of pollutants through to recycling, where resources are returned to the manufacturing cycle (Han et al. 2011; Zink and Geyer 2017). The steps needed for the introduction of circular economy systems, according to Sitnikov et al. (2015), are the creation of markets for recyclable materials, the development of the necessary services for customers, support for the reduction of waste and the restriction of non-recyclable materials. It must be emphasised that there are many "ideas" relating to the circular economy that share a central theme yet differ in their results and their optimal implementation (Mc Arthur 2016). (a) According to certain authors (Mc Arthur 2015; McKinsey et al. 2014; Morgan and Mitchell 2015), the circular economy focuses on economic growth potential based on the efficient use of resources. (b) The second direction, e.g. Allwood et al. (2014) presents the opinion that it is necessary to focus on production and manufacturing processes when implementing the circular economy. (c) The third direction is presented by authors such as Nansai et al. (2014), who believe that the circular economy lies in minimising waste and the exploitation of resources.

The increasing amount of waste generated and the subsequent environmental sanctions on the storage of call for worldwide attention in the interest of innovative industrial applications (Mohammadinia et al. 2019). The experience of firms who apply circular principles in their processes has shown that such steps can also provide considerable revenues. The French carmaker Renault, for example, has managed to reduce its energy and water consumption by 85%, by starting to use and repair old cars instead of producing new ones. As a result of its savings on material and energy, Renault has managed to offer its customers a 30–50% cheaper product of the same quality (Thuermer 2018).

In the Czech Republic, the development of the circular economy is influenced primarily by the European Union and its policy aimed at supporting sustainable development. The EU *Generation Awake* campaign was held between 2011 and 2015, to draw attention to the problems associated with waste. In 2014 the European Commission issued a communication on the so-called circular economy entitled "Towards a circular economy: A zero waste programme for Europe," where, according to European Commission plans Europeans should be recycling 70% of municipal waste and 80% of packaging waste by 2030 (Environment 2014). The most important research in the Czech Republic was carried out in 2012 by Henkel ČR in collaboration with the research agency GfK, a survey relating to environmental protection and conducted amongst representatives of enterprises operating in the Czech Republic. The survey showed that a total of 71% of firms operating in the Czech Republic have a long-term sustainable development strategy. Companies focus most on reducing energy consumption (77%), reducing the production of waste (70%) and stressing the link between sustainability and the company and its products (59%) (Mediaguru 2012). According to research conducted by Rais et al. (2016), 21.8 million tons of

business waste were generated in the Czech Republic in 2016. It fell by 6.2% in comparison with 2015. With an increasing volume of production, this means that enterprises are striving to keep on processing discarded material.

2.2 Life Cycle Assessment

The best-known method of recording the circular economy is Life Cycle Assessment (LCA). This is a method enabling an enterprise to record what happens to discarded products and discarded manufacturing equipment. The LCA model is one of a firm's the basic instruments of corporate social responsibility (Brander et al. 2019). The term Life Cycle Assessment means the life journey of a product from the development department's design through to the dumping of the non-functional product of parts of that product in a landfill or its disposal in an incineration plant at the end of its lifetime (Stevanović-Čarapina et al. 2011). The creation of the basic LCA principles was initiated by "The Society of Environmental Toxicology and Chemistry." The result was a publication entitled "Guidelines for Life Cycle Assessment," which was also adopted by the Ministry of the Environment of the Czech Republic. That methodology subsequently became the basis for the creation of the ISO 14040 series of standards. Under the Czech legislation, the methodology of assessing a product's life cycle is underpinned in seven international standards, ISO 14040 to 14049 (ISO 14040 2006). Comparison of the various life cycles of the same product enables one to then determine what raw materials, what energy source and what means of manufacturing, distribution or disposal will in that case have the least adverse impact on the environment. The advantage of the LCA model is that it provides the enterprise with objective results. This information may be provided to other stakeholders around the enterprise.

According to ISO (2012), the most commonly used LCA model has four phases:

1. Determination of the objectives and anticipated use of the results. This defines a procedure for determining the quality of the study. The scope should be set so as to match the designated objective.
2. The inventory life cycle analysis is the collection of processing of data quantifying the consumption of energy and materials, the production of pollutants, waste and other outputs for the duration of the product life cycle or processes.
3. An environmental impact assessment, providing both quantitative and qualitative assessments of the impact of products or processes on human health and the environment.
4. Interpretation of life cycle based on the results of the previous phases. The results are presented in a final study, tables or graphs. The aim is to use the results to propose changes in the individual phases of the life cycle in order to reduce the adverse impact on the environment.

In the developed world, the question of environmental sustainability is one of the most topical issues of the present day. The idea of the circular economy combines the environment with the economy. The circular economy is the infinite use of resources already once acquired. It involves putting products and manufacturing equipment at the end of their LCA back into the manufacturing process. Governments spend a considerable amount of money to promote a recycling lifestyle in order to maximise the benefits of recycling (Ma et al. 2019). This is the highest level of environmental business management. Sources from abroad show that involvement in the circular economy means an increase in costs in the short term. In the long term, however, the circular economy means a reduction in costs

and also increased competitiveness if the enterprise uses its behaviour for marketing (ICE 2019). The Czech Institute of Circular Economy presents a model of the LCA in Fig. 1.

Implementation of the LCA allows the identification and quantification of all the company's environmental impacts associated with its product, from the extraction of the raw materials, its manufacture, its use, through to the end of its life and its disposal, in all phases of its life cycle. However, it is important to bear in mind that the LCA is a tool aimed at supporting the decision-making process and not a decision-making method in itself. Use of the LCA model requires a relatively large quantity of data, which are complicated and costly to collect.

2.3 "3R" model

The main idea in the circular economy is to put discarded material back into the manufacturing process. This discarded material can be used at three levels using the "3R" (Renovation–Reuse–Recycle) method, comprising an economic code of conduct.

1. Renovation this is the lowest level of treating discarded material, with the lowest costs for reuse in manufacturing. Renovation is a process whereby a worn or otherwise damaged product (manufacturing equipment) is restored to its original geometric shape, which can then be reused in manufacturing (Jurac and Zlatar 2013). Renovation is an important part of measures aimed at alleviating climate change and establishing a sustainable relationship with our planets.

2. Reuse this is the second level of treating discarded material, which involves higher reconstruction costs. In the case of manufacturing equipment, this means general repairs, after which the manufacturing equipment is reinstalled in production. In the case of discarded products, this again involves total reconstruction, which is carried out with more expensive products. The Reuse principle means reusing products and packaging materials. Manufacturers and designers who follow the principles of the circular economy should focus primarily on designing products that are durable and reusable, i.e. on sustainable design. There are three options for the application of the circular economy in manufacturing and manufacturing processes (1) extending the lifetime of the product, (2) establishing centres that mediate returns of non-functional goods, and (3) strengthening cooperation between those centres and manufacturing (Rong and Ling 2012). However, the basis is

Fig. 1 Model of the circular economy. *Source*: Czech Institute of Circular Economy

involvement in the LCA, where the extended lifetime must be taken into account during the design process. However, this strategy often contradicts the strategies of certain enterprises, which, on the other hand, want to shorten the LCA and thus increase their sales intervals (Xiyuan and Lei 2011). On the other hand, enterprises that *reuse* achieve competitive advantages from the presentation of such socially responsible behaviour. This boosts their goodwill and thus improves the position of the brand, which has a positive impact on the enterprise's commercial success (Bocken et al. 2016; Wang et al. 2005).

3. Recycling this is the third level of treating discarded material. This involves the total conversion of a damaged or non-functional product (manufacturing equipment) into basic raw materials. It then enters manufacturing as a substitute for primary raw materials, i.e. as a secondary raw material (Brožová 2010). The Recycle principle means reusing products as resources when they reach the end of their lifetime. However, with reuse and recycling, it is essential to be able to recognise the limit on waste exploitation efficiency, which has certain limitations. The increasing demands of society and customers are resulting in primary resources becoming exhausted and a rise in the amount of waste generated. The disposal and minimisation of waste, including recycling and reuse, must be part of any manufacturing process or equipment that uses the circular economy (Gujer 1991; Hagelüken et al. 2016). According to Lavee (2007), recycling has undeniable benefits for human society. Less waste to be disposed of would then extend the lifetime of landfills and reduce soil, air and water pollution (da Cruz et al. 2012). Europe is currently losing approximately 600 million tons of materials a year in waste that could be recycled or reused. Only approximately 40% of EU household waste is recycled (CE 2017). At present, the use of plastics is on the rise, but recycling effectiveness is lagging behind—less than 25% of plastic waste is recycled, and approximately 50% ends up in a landfill. Waste from electrical appliances and electronics equipment is also increasing, with an estimated growth trend of 3–5% per year (Cucchiella et al. 2015).

3 Methodology

The research methodology was set up based on a definition of the main objective, which was determined in four research questions. On the basis of this, the methodology was divided up into three parts. For the sake of clarity, Fig. 2 shows the conceptual framework, presenting the sequence of the individual parts of the research. One part always had to be assessed before the following part could start.

The first part comprised the secondary research, sourced from domestic and foreign literature, scientific articles and the internet. This enabled the creation of an information base for the topic in question. A year-long analysis of previously published research served as the basis for orientation in the topic. The main sources were the Scopus, Proquest, Science Direct and Web of Science databases. Czech and foreign literature also served as another source. The most interesting results of the secondary research are presented in the literary overview of this paper. The content analysis method was applied to the information obtained. A content analysis is an analysis of the basic directions of a document, in this case qualitative in nature. The content of the document expressed in words in natural language is converted into substantive selection data. The content analysis is followed by a synthesis, which again reunifies the fragmented information. In this case, it leads to the creation of a model of the circular economy (Krippendorff 2018).

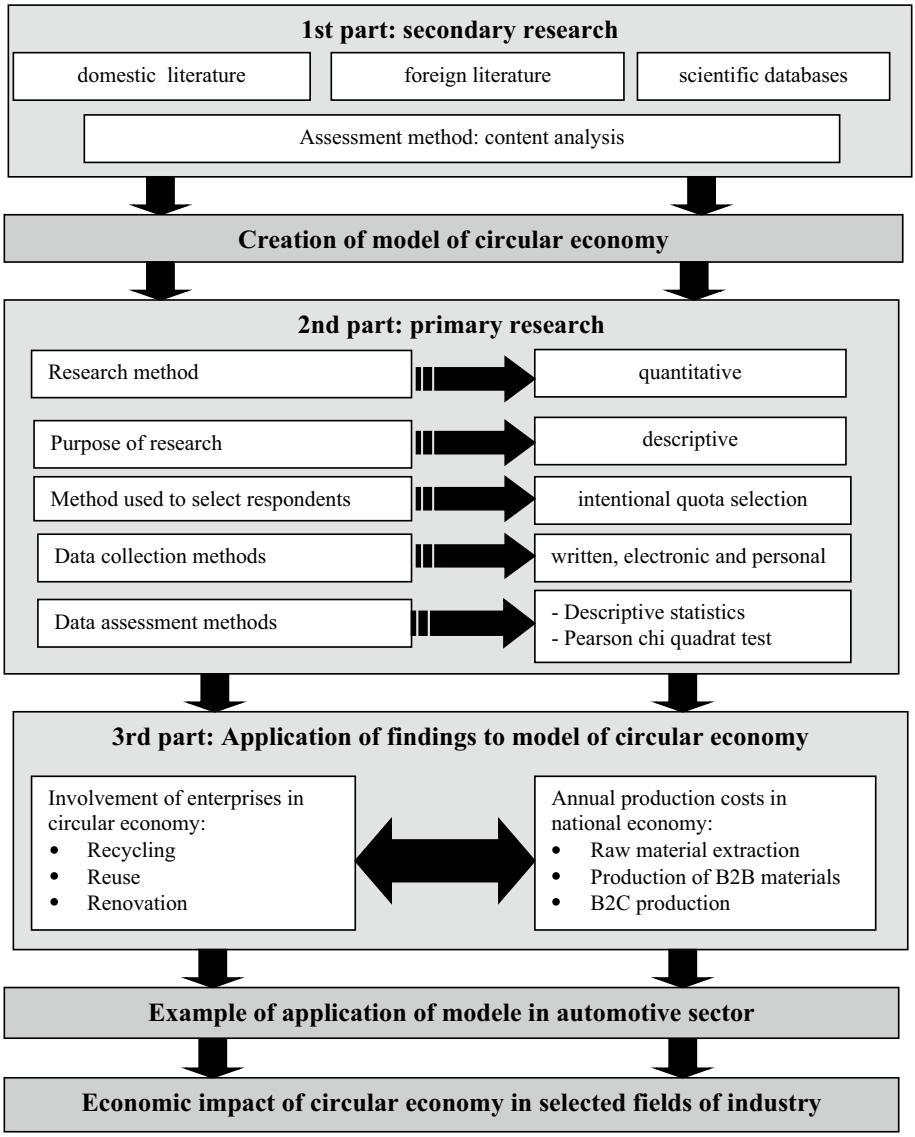

Fig. 2 Conceptual framework of the research

The second part comprises the primary research, which was conducted using quantitative data collection. Quantitative research uses quantification and statistical assessment methods. The logic of the quantitative research was deductive, as the research required thorough standardisation, to ensure a high degree of reliability. The purpose of the research was descriptive, as it explored the level of frequency (Saunders et al. 2002). Respondents were purposefully selected and not chosen randomly. This was a quota selection, with the selection criterion being field of activity. The basic set comprised all enterprises in the Czech Republic listed in the commercial database

purchased by the Faculty of Economics. From this database, enterprises were selected from six key sectors and were queries using an electronic questionnaire and questions in person. The rate of return for the electronic questionnaire was very low, so the questions were then asked in person. The advantage of personal questions is that the return rate of the questionnaires is high (King et al. 2018). A questionnaire was drawn up containing closed questions. Two classification questions were used for the application of the model in practice. The first related to the field of business and the second to the enterprise's involvement in the circular economy. These were followed by questions on the reasons for their involvement and the extent to which enterprises apply the circular economy. The questionnaire ended with questions on the costs that enterprises invest in the circular economy. The assessment was performed using the descriptive statistic method, which takes account of absolute and relative frequency, average and standard deviation. The method used to test statistical hypotheses for the classification questions and to determine differences in the sets was the Pearson's Chi-squared test. The statistical program SPSS was used.

The third part of the research applies the resulting data to the model of the circular economy. This was the most important part of the research, where the data obtained were used for the economic assessment. The functionality of the model was tested using data from the Czech Statistical Office, which related to costs in the various sectors. The latest data are for 2017 and are mandatorily processed in all EU countries. These data were linked to the relative frequencies determined by the research. The procedure used to determine data for the application of the circular economy model:

1. The total costs for the sector are divided up according to the type of market. The first part comprises enterprises from the industrial market (B2B) and the second part consists of enterprises operating on the consumer market (B2C). The costs of extracting raw materials are also stated. The figures are for 2017, sourced from the Czech Statistical Office.
2. The costs divided up into the individual sectors according to B2B and B2C are then broken down according to their purpose. The research covers selected costs of tangible fixed assets and also partially current assets. These comprise all the costs of manufacturing equipment, packaging and everything that the firm can discard as waste at the end of its lifetime. This does not include products or semi-finished products that are further processed or sold to customers.
3. The percentage level of company involvement in the circular economy is converted to a specific monetary value. The proportion of involvement in recycling, reuse, renovation and waste is then calculated for the costs determined in the previous step. The proportion of costs in the circular economy is calculated in relation to the costs of tangible fixed assets and partly also current assets divided between the B2B and B2C market.
4. Calculation of additional costs incurred by enterprises joining the circular economy, divided up into three parts: renovation, reuse and recycling. The data used come from the surveys specified in Table 6 compared with the costs for the tangible fixed assets sector and partly also current assets divided between the B2B and B2C market.

This calculation process is repeated for all six sectors of the economy, although this paper also shows losses/profit resulting from involvement in the circular economy in the individual fields.

4 Model of the circular economy

The theoretical part presented various views of the circular economy. The aim of the theoretical part was to find a contemporary concept of the circular economy that could, if needed, be used to draft a working model and meet the main objective: To define a suitable model that could be used to determine the efficiency of the circular economy in business practice. The model was defined using the LCA model, which does not take account of the economic or social aspects of a product, but the approach regarding the lifetime of the product. The LCA model incorporated a 3R model, which portrays the use of discarded material at three levels, depending on processing depth. These are renovation, which involves minimal treatment of the discarded material, reuse, involving more significant processing, and the conversion and recycling of discarded material, meaning its absolute transformation into basic raw material. The model was defined on the basis of the content analysis, involving members of the research team. This connection explicitly shows all the options for putting discarded material back into the manufacturing process. Figure 3 shows the model for the use of the circular economy.

The four basic stages of the processing and use of products, which form the top part of the model, were selected from the general LCA model. The first stage is the extraction of raw materials and the costs of the extraction of primary resources. The second stage is the production of materials and the costs associated with the production of materials. This is the industrial market (B2B), where a product may be offered in the form of a raw material, semi-finished product or finished product to be assembled into a more complex product. The third stage is manufacturing, which is a consumer market (B2C), where the customers are the end users. Once again, it is necessary to identify costs in this stage. The last stage is use of the product by consumers through to the end of its lifetime. Here, the costs of purchasing the product are recorded. This horizontal division is used to separate the life of the products in the top part and the discarding of the product in the bottom part. In the bottom part of the model, the division is associated with the depth of the transformation of the discarded material. There

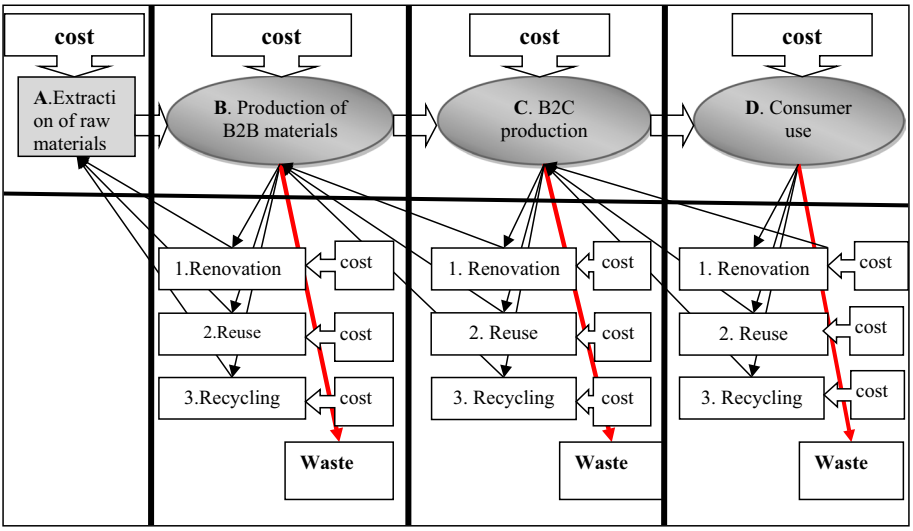

Fig. 3 Model of the circular economy

are three possible further uses and one variant, where the enterprise treats the discarded material as waste only. If the enterprise or consumer is part of the circular economy, the discarded material is transformed into one of three possible variants. If the enterprise or consumer is not part of circulation, the discarded product or material ends up as waste. The model of the circular economy is also divided up vertically. The 3Rs (renovation, reuse and recycling) are allocated to each of the three parts of the LCA. All the stages involved in the transformation of discarded material incur additional costs. This means that renovation is associated with the lowest costs, while recycling involves the highest costs. However, this premise does not necessarily apply in full, as in some sectors the costs may differ greatly in the various phases.

5 Results of the primary research

The primary research involved a total of 335 enterprises, with answers obtained from 205 enterprises. This is a very high rate of return, 63.2%, which was achieved by a combination of an electronic questionnaire and questions in person. The most important enterprises in the Czech economy were contacted. The aim was to obtain answers from enterprises from the six most important sectors of the Czech economy.

5.1 Enterprise involvement in the circular economy

The basic classification question when collecting the data focused on whether enterprises are part of the circular economy. The researchers used this question to determine how many enterprises in the Czech Republic are part of the circular economy. This was the first research question. This question was therefore at the start of the questionnaire and served for classification purposes. Figure 4 shows the results.

The results show that 29% of enterprises, which in absolute terms means 60 enterprises, apply only a passive environmental approach. This means that these enterprises only comply with the mandatory requirements stipulated by the Czech or EU legislation. In contrast, 71%, i.e. 145 enterprises, are environmentally active and take an active approach. This means that not all their discarded material ends up as waste, but is re-treated or reprocessed for further use.

5.2 Influence of classification questions

The survey used a classification question, relating to the sector in which the enterprise operates. This question was very important for the application of the model, as it served to identify differences in the answers. The second research question was as follows: *Is there any difference in the results in the assessment of the amount of discarded material in the individual fields?* Although the respondents in the research were selected using the intentional research method, statistical induction was performed, where respondents must be selected randomly.

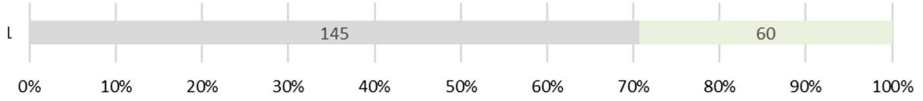

Fig. 4 Enterprise involvement in the circular economy

Therefore, the results of the statistical hypothesis testing may only be taken as a supplement. Table 1 shows the numbers of respondents in the individual fields divided into the B2B and B2C markets.

The table clearly shows that in all the sectors divided up into the B2B and B2C markets, answers were received from a minimum of ten enterprises. The most responses came from the automotive industry, which is the dominant sector of the Czech economy. The following hypothesis was set to determine the differences in the answers amongst the sectors:

H0 In the assessment of the sectors, there are no statistically significant differences between the answers.

H1 Non H0.

The answers to these questions were subjected to the Pearson's Chi-squared test. The assessment was performed at a significance level of $\alpha = 0.05$. The resulting value was $p = 0.011563$. It may be said that there are significant differences in the answers amongst the sectors. Overall, it may be said that involvement in the circular economy varies greatly amongst the sectors.

5.3 Reasons for being part of the circular economy

The research identified differing opinions regarding the reasons for being part of the circular economy. The third research question was therefore defined as follows: What are enterprises' reasons for joining the circular economy? This was an open question and was intended to supplement the scientifically designed research. The most frequent reasons for being part of the circular economy may be summarised into four areas:

- Public pressure to reduce the enterprise's environmental impact.
- Inclusion of environmental behaviour in marketing communication.
- Creation of new innovation opportunities.
- Profitability.

The first reason was the growing adoption of Corporate Social Responsibility by enterprises. If enterprises behave in a socially responsible manner, they exploit that fact in their

Table 1 Distribution of respondents by sector. *Source*: own

	Industry sector	B2B	B2C	%
1	Manufacture of motor vehicles, trailers and semi-trailers	18	13	21.4
2	Manufacture of fabricated metal products, except machinery and equipment	13	10	15.9
3	Manufacture of machinery and equipment n.e.c.	11	10	14.5
4	Manufacture of computer, electronic and optical products	14	12	17.9
5	Manufacture of rubber and plastic products	11	10	14.5
6	Manufacture of electrical equipment	10	13	15.9
Total		77	68	100
p value; ($\alpha = 0.05$)		0.011563		

marketing, which was the second reason. In many promotional campaigns, Corporate Social Responsibility is used as suitable content. The next reason is innovation associated with digitisation. The last reason is economic, where enterprises believe that involvement in the circular economy is profitable.

On the other hand, enterprises stated reasons why their involvement in the circular economy was problematic. There were a total of four main areas:

- Economic impact.
- Difficult for management to make changes.
- Identification of environmental risks.
- Cannot be used for a certain specific type of material.

Many enterprises were of the opinion that the further processing of discarded material rather than getting rid of it as waste results in a considerable increase in costs, particularly initial costs. Another reason is the problem in pushing through the strategic decision that would lead to the change. This decision is associated with an increase in initial costs, i.e. with a risk, a point enterprises also raised. The last reason is that certain materials cannot be processed any further.

6 Data for application of the model

The presented model of the circular economy was designed for practical use. It enables calculation of the economic impact resulting from involvement in the circular economy. The model includes data from the primary research and data acquired by the Czech Statistical Office. The model is only partially used in this paper, in order to identify the quantity of enterprises involved in the circular economy during the production of materials (B2B) and during manufacturing (B2C). This is involvement in the field of tangible fixed assets, which means movables or sets of movables with a separate technical and economic purpose, the purchase price of which is higher than 1538.5 EUR and whose operational and functional lifetime is longer than 1 year. The calculation also includes current assets from the Stocks section, in four parts:

- auxiliary substances = materials that also pass directly into the product but do not constitute its essence
- operating substances = materials essential for the operation of the enterprise (fuels, lubricants…)
- spare parts = items intended to restore a tangible asset to its original state
- packaging = used to protect and transport purchased material, goods and products

Both tangible fixed assets and some current assets are items that the enterprise may decide to scrap as waste or to reuse at their end of their lifetime. Other current assets in the form of own products, semi-finished products and goods intended for consumers and intended to be disposed of by consumers do not appear in this model.

This chapter uses data from the Czech Statistical Office. Other data are sourced from the primary research. As the application of the model is divided up by sector, the results of the research must be divided up in the applied part of the paper by sector. In the primary research, information was obtained from 145 enterprises presenting themselves as being

involved in the circular economy. The assessment was performed in the six most important sectors of the domestic economy, as confirmed by data from the Czech Statistical Office. These are the sectors with the highest turnover in the national economy (CSO 2017). The tables show only relative frequencies as percentages, to enable the data obtained from the research to be used for the distribution of costs.

6.1 Annual sector costs

In order to apply the model in practice, it is essential to know hard data about the national economy. Every EU Member State must collect data on economic indicators, across all sectors. For the purposes of the research, this means total costs in the individual fields of the manufacturing industry. The manufacturing industry is divided upon the basis of the standard applicable in the EU, i.e. the Statistical Classification of Economic Activities (NACE). The NACE classification is a five-digit code. The first four levels are derived from the international standards; the fifth is national. The first two levels are used for the purposes of the research. Sections "B" and "C" are selected from the first level, i.e. the extraction of raw materials and the manufacturing industry. The second section then contains 24 groups of sectors. The six most important of these sectors are then selected. Table 2 presents the annual costs in the most important sectors of the manufacturing industry. The Statistical Office does not divide up section "B" and the data are shown merely as aggregate. Section "C" is then divided up into the percentage of costs on the industrial and consumer markets.

The Czech economy is highly pro-export. Engineering is the most important sector in the manufacturing industry for the Czech economy. The automotive industry in particular is the dominant sector of the Czech economy. This is also reflected in the distribution of costs, which is clearly dominated by the manufacturing of motor vehicles. These hard data serve as the basis for the other calculations. Costs in the extraction of raw materials are significantly lower than in the manufacturing industry, due to the fact that the Czech Republic has a lack of primary raw materials. Most raw materials are imported from abroad.

6.2 Distribution of costs by sector

The hard data obtained by the Czech Statistical Office had to be divided up into two parts—for the industrial market and the consumer market. For both markets, it was then necessary to determine the percentage of total costs in the individual fields. For the purposes of the research, the total costs were enterprises' costs on investment equipment and on some current assets. With its own material, the enterprise can decide whether to dispose of it as waste or whether to continue using it. Data from the primary research were used for the distribution of costs in the individual fields of the manufacturing industry. The resulting distribution by sector is shown in Table 3.

The research showed that both types of market enterprises invest more costs in investment equipment. The highest mean costs are on investment equipment in the industrial market. In contrast, the lowest costs are on other current assets in the industrial market. The total means of costs, however, serve merely as additional information. The important factor for putting together the model of the circular economy was the distribution of costs in the individual fields. The sum total of the costs of investment equipment and the costs of other current assets was used to apply data to the model. The costs were aggregated for B2B and B2C separately. The aim was to determine the costs of everything that the enterprise puts into waste, either immediately or after some time. This means what area of waste

Table 2 Costs in sectors for 2017 in million EUR. *Source*: CSO

	Sector of manufacturing industry	Section "B" extraction of raw materials	Section "C" manufacturing industry	Distribution of section "C" costs	
				B2B (%)	B2C (%)
1	Manufacture of motor vehicles, trailers and semi-trailers	3155.15	46,754.46	51	49
2	Manufacture of fabricated metal products, except machinery and equipment		13,389.62	65	35
3	Manufacture of machinery and equipment n.e.c.		13,225.96	77	23
4	Manufacture of computer, electronic and optical products		13,159.04	49	51
5	Manufacture of rubber and plastic products		11,966.65	45	55
6	Manufacture of electrical equipment		11,240.92	39	61

Table 3 Percentage of costs of "Investment equipment" and "Circular Material" in relation to total costs for 2017. *Source*: own

	Manufacturing industry sector	B2B			B2C		
		Investment equipment (%)	Other circular material (%)	Total (%)	Investment equipment (%)	Other circular material (%)	Total (%)
1	Manufacture of motor vehicles, trailers and semi-trailers	45	2	47	38	11	49
2	Manufacture of fabricated metal products, except machinery and equipment	59	4	63	16	8	24
3	Manufacture of machinery and equipment n.e.c.	50	2	52	29	6	35
4	Manufacture of computer, electronic and optical products	66	3	69	40	5	45
5	Manufacture of rubber and plastic products	33	4	37	35	8	43
6	Manufacture of electrical equipment	38	3	41	33	7	40
	mean	48.5	3.0	51.5	31.8	7.5	39.3

the enterprise can control itself. The term "own material" is used hereafter for these two groups.

6.3 Level of company involvement in the circular economy in sectors

Data from the primary research were again used to identify the level of involvement in the circular economy. Enterprises presenting themselves as being part of the circular economy had to divide their discarded products up into four parts. Each part means a different degree of processing for the discarded products. The stages are a) Renovation b) Reuse c) Recycling. These three stages are supplemented by a fourth variant, waste. The waste category must be added to the table, as in most cases enterprises are only partly involved in the circular economy, and a proportion of materials ends up as waste. The enterprises we questioned are divided up by customers on the B2B and B2C markets. Information on involvement in the circular economy is sorted according to the sectors (1–6) in Table 4 for both markets.

The most material on the B2B market that enterprises can sort ends up as waste, i.e. almost half. Most firms recycle discarded material in connection with the circulation process. However, in this case the mean does not have any great informative value, as the standard deviation is relatively low. This means that the answers are very heterogeneous, and depend on the sector. The means are lower with reuse and renovation, but again the standard deviation is high. It may, therefore, be said that current involvement in the circular economy on the B2B market varies greatly from sector to sector. A great proportion of discarded production ends up as waste, including in the case of companies that present themselves as being part of the circular economy.

Unlike the B2B market, where the most discarded material ended up as waste, the most discarded material is recycled on the B2C market. However, the mean has little informative value since, as sd shows, the numbers of firms that recycle vary considerably from sector to sector. Almost the same percentage of material ends up as waste. Lower percentage means can be seen in reuse and renovation. It may therefore be said that current involvement in the circular economy varies greatly, depending on the sector. The research confirmed that there is a greater involvement in the circular economy in companies doing business on the B2C market, where enterprises most recycle their discarded material.

Table 4 Percentage level of company involvement in the circular economy for B2B and B2C. *Source*: own

B2B				Sector no.	B2C			
Recycling	Reuse	Renovation	WASTE		Recycling	Reuse	Renovation	WASTE
17%	16%	4%	63%	1	20%	13%	19%	48%
9%	25%	19%	47%	2	11%	52%	21%	16%
8%	24%	22%	46%	3	4%	32%	30%	34%
46%	14%	14%	26%	4	35%	11%	21%	33%
38%	25%	2%	35%	5	55%	6%	0%	39%
29%	10%	3%	58%	6	31%	7%	15%	47%
25%	19%	11%	46%	Mean	37%	14%	14%	35%
14.3	5.9	8	12.6	SD	20.92	15.99	10.79	13.5

6.4 Additional costs on involvement in the circular economy

The circular economy also entails additional costs in the individual stages. The data to determine additional costs were sourced from the primary research. The enterprises were asked what other costs they have to expend to join the individual parts of the circular economy. For processing in the model, the enterprises had to compare their additional costs on involvement in the circular economy with the total amount of costs expended on discarded material, i.e. not on total costs, but merely on costs that the enterprise could itself control. The questions concerned the detailed distribution of these costs on amongst renovation, reuse and recycling. The enterprises questioned were divided up according to their focus on B2B and B2C. Table 5 presents distribution by sector.

The highest additional costs on the B2B market are associated with the recycling and reuse of discarded material. This also corresponds to the level of involvement shown in Table 4, where these two levels of processing discarded material are also the most widely used. This result could be expected, as on the B2B market products are packed onto pallets in large numbers and the pallets can then be reused. As sd shows, the results are relatively heterogeneous. Additional costs on renovation are considerably lower, including in comparison with B2C. Enterprises on the B2C market have higher additional costs on the circular economy. Higher additional costs reflect a greater involvement in the circular economy. The highest additional costs are associated with recycling, as on the B2B market. Considerably lower additional costs are again expended on reuse, even lower than on the B2B market. Costs on renovation are the lowest, although they do exceed the additional costs of recycling on the B2B market. The order of size is the same for both markets, which could be expected, as recycling is the highest level in the transformation of discarded material, which often tends to entail the highest costs. Reuse and renovation involve a lower level of transformation and thus lower costs.

7 Application of the model in practice

After obtaining all the data needed to complete and check the functionality of the model, the total costs must be gradually converted for the individual parts of the model according to their percentage. This involves a combination of hard data from the Czech Statistical

Table 5 Percentage distribution of additional costs for B2B and B2C. *Source*: own

B2B			Sector no.	B2C		
Recycling	Reuse	Renovation		Recycling	Reuse	Renovation
3.4%	2.4%	0.8%	1	4.1%	2.3%	1.5%
1.2%	4.1%	3.1%	2	3.0%	7.9%	4.6%
2.1%	5.3%	3.2%	3	4.2%	5.3%	3.2%
6.8%	2.4%	2.0%	4	6.8%	0.5%	2.2%
6.7%	5.5%	1.1%	5	9.6%	0.8%	0.0%
3.4%	2.1%	0.9%	6	6.2%	3.4%	3.0%
3.9%	3.6%	1.9%	Mean	5.1%	3.4%	2.4%
2.1	1.4	1	SD	2.8	2.6	1.4

Office and the relative frequencies ascertained from the primary research presented in chapter 5. The calculation procedure is divided into four parts and is presented in detail in the methodology in chapter 2. The calculation is presented in detail for just one sector, i.e. manufacture of motor vehicles. The total annual costs expended on production in this sector in 2017 are 46,754.46 million EUR. Only the results will be presented for the other sectors.

1. Manufacture of motor vehicles TC = 46,754.46 million EUR.
   Distribution of total costs for B2B = 51%; 23,844.78 million EUR.
   Distribution of total costs for B2C = 49%; 22,909.69 million EUR.
2. Costs of own B2B material = 23,844.78 million EUR. 47% = 11,207.04 million EUR.
   Costs of own B2C material = 22,909.69 million EUR. 49% = 11,225.75 million EUR.
3. B2B savings arising from involvement in the circular economy = 11,207.04 million EUR.
   Recycling 17% = 1905.20 million EUR.
   Reuse 16% = 1793.13 million EUR.
   Renovation 4% = 448.28 million EUR.
   WASTE 63% = 7060.44 million EUR.
   B2C savings arising from involvement in the circular economy = 11,225.75 million EUR.
   Recycling 20% = 2245.15 million EUR.
   Reuse 13% = 1459.35 million EUR.
   Renovation 19% = 2132.89 million EUR.
   WASTE 48% = 5388.36 million EUR.
4. B2B additional costs of involvement in the circular economy = 11,207.04 million EUR.
   Recycling 3.4% = 381.04 million EUR.
   Reuse 2.4% = 268.97 million EUR.
   Renovation 0.8% = 89.66 million EUR.
   B2C additional costs of involvement in the circular economy = 11,225.75 million EUR.
   Recycling 4.1% = 460.26 million EUR.
   Reuse 2.3% = 258.19 million EUR.
   Renovation 1.5% = 168.39 million EUR.

7.1 Assembly of the applied model

The complete model of the circular economy includes products from the extraction of their raw materials through to the end of their lifetime and their subsequent decommissioning. This chapter presents the part of the model that analyses the behaviour of enterprises. The main source for the model is data from the Czech Statistical Office, which determines the annual costs of: A. extraction of their raw materials, B. production of materials (B2B) and C. production (B2C). The calculated values are entered into the model. Figure 5 shows the resulting model for the sector manufacture of motor vehicles.

Involvement in the circular economy can result in savings on the cost of extracting raw materials. Enterprises replace primary raw materials by reusing discarded material during manufacturing in the form of recycling, reuse or renovation. The model is first used to determine gross savings. However, these savings are accompanied by additional costs on involvement in the circular economy. In the model, discarded material is divided up into

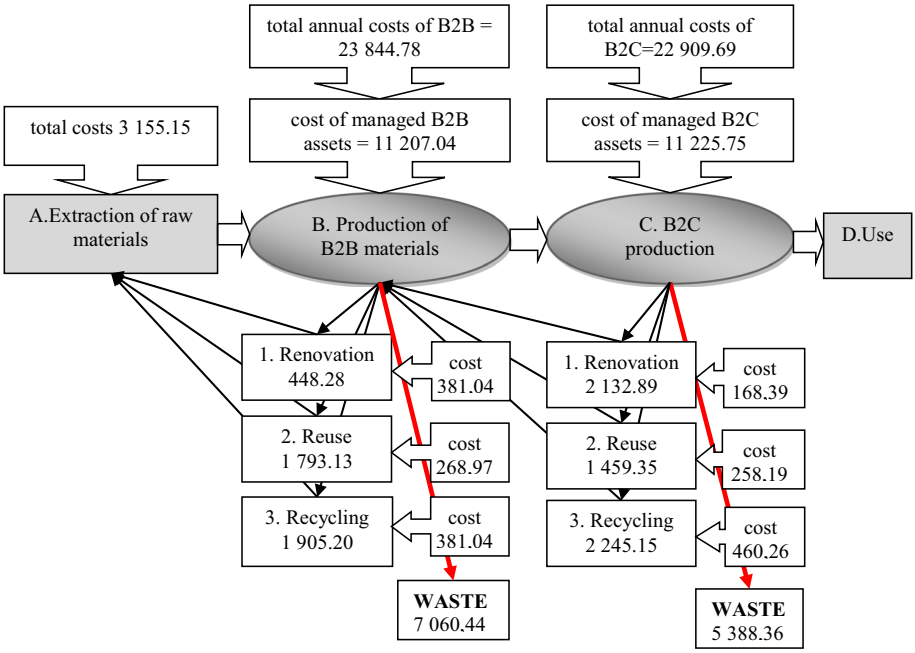

Fig. 5 Model of the circular economy for the manufacture of motor vehicles (2017 in mil. EUR)

three levels. Recycling is the highest level of treatment, which often tends to entail the highest costs; Reuse is the lowest level of treatment and Renovation is the least demanding process in treating discarded material, which often involves packaging or pallets. Finally, it is necessary to compare the savings with the costs of processing materials. Additional costs on the transformation of discarded material are deducted from the costs saved. The precise calculation results in the amount of net savings made through involvement in the circular economy. Table 6 presents savings, costs of involvement and net savings.

For the global economy enterprises' gross savings mean savings on primary raw materials. This can often result in less dependence on suppliers of raw materials. Higher gross savings are generated by enterprises in the automotive industry on the B2C market. This amounts to 5837.35 million EUR, which is more than half of the total amount of costs on managed assets, which were 11,225.75 million EUR. The total gross savings of enterprises in the automotive industry on the B2B market were 4146.58 million EUR, which is more

Table 6 Net savings resulting from the circular economy in the manufacture of motor vehicles (2017 in mil. EUR). *Source*: own

	B2B				B2C			
	Recycling	Reuse	Renovation	Total	Recycling	Reuse	Renovation	Total
Gross savings	1905.19	1793.12	448.27	4146.58	2245.12	1459.35	2132.88	5837.35
Additional costs	381.04	268.96	89.65	739.65	460.23	258.15	168.38	886.77
Net savings	1524.15	1524.15	358.62	3406.92	1784.88	1201.19	1964.50	4950.58

than a third of the costs of own material, at 11,207.04 million EUR. If the individual stages of the circular economy are evaluated from the viewpoint of gross savings, enterprises in the automotive industry from the B2C market do most recycling and renovation, totalling 4378 million EUR. The result of the savings, 1459.35 million EUR, comes from Reuse. The highest proportion of overall savings in the sector on the B2B market is from Recycling and Reuse; both are approximately the same and together amount to savings totalling 3698.31 million EUR. The rest of the gross savings comes from Renovation. Additional costs of treating discarded material to be returned to production are higher on the B2C market than on the B2B. The distribution of additional costs corresponds to the gross savings in both total costs and in the individual parts involved in the processing of discarded material. After also taking account of the net savings achieved by enterprises in the automotive industry, it may be said that all involvement in the circular economy is profitable. When comparing individual net savings, these are higher on the B2C market specifically, enterprises make the highest absolute net savings from renovation. The Czech Statistical Office states that in the Czech Republic the costs of the extraction of raw materials are 3155.15 million EUR. If this sum is compared with savings from the automotive industry alone, which total 8357.5 million EUR, the savings are considerably higher than the entire annual costs of raw material extraction.

7.2 Economic benefit of the circular economy in selected fields

The previous chapter presented the process of calculating and defining the model for the sector manufacture of motor vehicles. In the project, models were calculated and defined in a similar manner for the other fields that play an important role in the Czech economy. The process was applied to a total of 6 of the most important sectors of the domestic economy. Table 7 shows only the net savings made in the individual fields.

To summarise, the resulting figures in Table 7 present net total savings, in almost all sectors. It is only in the manufacture of machinery and equipment sector that a loss is identified on the B2C market in Recycling. In the manufacture of rubber and plastic products sector no enterprise carries out renovation on the B2C market and so the result is zero.

Assessment of the research allows us to answer the fourth research question: *Is it economically beneficial for enterprises to join the circular economy? In what fields?* Altogether, the enterprises in these six sectors achieved net savings of 23,179.79 million EUR. Total costs in these sectors were 109,736.65 million EUR, which means that

Table 7 Net savings in selected fields of the Czech economy (2017 in mil. EUR). *Source*: own

Sector no.	B2B				B2C			
	Recycling	Reuse	Renovation	Total	Recycling	Reuse	Renovation	Total
1	1524.16	1524.16	358.63	**3406.94**	1784.89	1201.16	1964.51	**4950.55**
2	427.68	1145.96	871.80	**2445.44**	89.98	496.01	184.46	**770.44**
3	312.44	990.29	995.59	**2298.32**	− 2.13	284.27	285.34	**567.48**
4	1744.04	516.09	533.89	**2794.02**	851.64	317.10	567.76	**1736.50**
5	623.64	388.53	17.93	**1030.10**	1284.87	147.17	0.00	**1432.04**
6	460.14	142.00	37.75	**639.88**	680.21	98.74	329.13	**1108.09**
∑	**5092.09**	**4707.02**	**2815.58**		**4689.47**	**2544.44**	**3331.19**	

21.1% of discarded material is put back into the manufacturing process. This also means that the costs of raw material extraction are reduced by this amount, thus increasing the country's environmental sustainability. More savings are generated by the B2B market, with 12,614.69 million EUR, where the highest net profit is in the automotive industry 10,565.09 million EUR of net savings were identified on the B2C market, most of which again are in the automotive industry. The amount of savings in the automotive industry is due to the dominance of the sector in the Czech economy.

8 Discussion

The research entailed the study of many scientific studies focusing on the circular economy, particularly the involvement of industrial enterprises. The authors of those works (Passarini et al. 2014; Wang et al. 2005; Gricishen 2015; Lapytova 2004; Cheysova 1984; Petukhov et al. 2016; Antanenkova 2012; Panchenko 2016) clearly demonstrate that industrial enterprises have an adverse impact on the environment. This claim can be considered an axiom, i.e. an absolutely valid statement. The circular economy can be seen as a solution enabling industrial enterprises to reduce their adverse impact on the environment. In this paper we demonstrate the economic suitability of the circular economy, assuming an enterprise is part of it. A positive economic impact was proven in all sectors, and in almost all the stages involved in the transformation of discarded material, with the exception of two cases—see Table 7. The model counts the current costs associated with the use of already discarded material. On the other hand, there are the costs of purchasing the technology and process implementation. According to the authors (Enander 1995; Dutta 2004; Robinson 1986; Cheremisinoff 1995; Ivanova 2005; Nasakina 1999; Jasch 2008; D'Onza et al. 2016; Jachnik 2006) who focus on this method of environmental costs, these costs should not be included in the model. According to the authors, those acquisition long-term environmental costs should be quantified separately using classic investment evaluation methods, particularly the following dynamic methods: return on investment, payback method, net present value of investment, profitability index and internal rate of return.

According to the Czech Institute of Circular Economy (Fig. 1) and the authors (Nansai et al. 2014; Mc Arthur 2015; McKinsey et al. 2014; Morgan and Mitchell 2015; Allwood et al. 2014), the circular economy model is a circle comprising raw materials, design, production, distribution, consumption, collection, recycling and re-integration into production. Those models are too simple and do not cover how discarded material is processed, the costs of those processing stages, or additional costs. This paper presents a model that eliminates those shortcomings and includes all the missing data. The model presented here combines the extraction of raw materials, the B2B market, B2C market and consumption. However, the model is only applied to the B2B market and B2C market, as the research respondents were enterprises. Research into how waste is treated by consumers must be based on a survey focusing directly on consumers. Research (CE 2017) shows that 40% of waste comes from households and 60% from enterprises. However, this ratio varies from sector to sector and a detailed survey of consumers is therefore required, which is another potential topic for a study to follow-up on this research. Comparing other data with research conducted by the GfK agency in 2012, which was the last relevant research in the Czech Republic, the figures are very similar. The agency found that 71% of firms operating in the Czech Republic have a long-term sustainable development strategy, of which 77% of firms focus on reducing energy consumption, 70% of firms on reducing the amount of

waste they produce, and 59% of firms present their products as being sustainable. Moreover, in this research 71% of firms stated that they have long applied an environmental strategy. Comparison of the two surveys shows that the basic information obtained is very similar. It may be said that during recent years there has been no significant change in companies' environmental behaviour. Current research into environmental activities is moving into the circular economy, which means enterprises being directly involved in environmental activities.

9 Conclusion

In general, the main benefit of the circular economy may be summarised as a positive impact on environmental sustainability. Sustainability is the ability of biological systems to maintain diversity and productivity for an indefinite length of time. In the broader context, this means using discarded material instead of extracting raw materials. The Czech Republic does not have adequate natural resources; the Czech Statistical Office states that costs on the extraction of raw materials total a mere 3155.15 million EUR (CSO 2018). If this sum is compared with the savings determined in the six most important sectors of the economy during 1 year, calculated at 23,179.79 million EUR, theoretically the savings are almost eight times higher than the costs of extracting resources in the Czech Republic. As the Czech Republic is not rich in raw materials, these costs are saved in the import of raw materials.

Despite its extensive scope and complexity, the research cannot be considered as being representative from a statistical perspective. In order to acquire more precise data, the survey would have to be conducted amongst more businesses, which was not possible for this research. Even so, answers were obtained from 205 enterprises, with information from the 145 of those enterprises which were part of the circular economy. As the research used relative percentage frequency, the results can be extrapolated to cover all six of the most important sectors of the national economy. The methodology and procedure could serve as a template to enable data to be obtained and processed by the regulator, which is the state. That would be able to conduct representative research through the Czech Statistical Office. Data on the circular economy would be added to each annual compulsory company report. This would provide the regulator with data enabling it to support enterprises for being part of the circular economy. The paper presents a method for quantifying the costs saved that would otherwise be expended on the extraction of raw materials. To summarise, it may be said that a government policy focused on supporting enterprises involved in the circular economy would not only have an economic benefit, but also a positive social impact.

The main aim of the paper was to create a suitable model that could be used to determine the efficiency of the circular economy in business practice and apply that model across the most important sectors of the domestic economy. This aim was determined in four research questions that help to achieve the set objective. The scientific contribution of the model lies particularly in the linking of two approaches in the circular economy, which are the depth of treatment of discarded material in the form of 3R and the Life Cycle Assessment model. No one has made this link before and it is original. The specific results of the 3R model obtained from the primary research were included in the theoretical LCA model. This link results in a synergy effect, which can be regularly repeated. The procedure used to obtain information and the results could in the future service as the basis for the creation of methodology for the Ministry of the Environment. At present, however,

according to a declaration from the Ministry of the Environment, it is not one of the government's plans to certify any methodology. This approach should be changed, since, as a member of the EU, the Czech Republic is committed to recycling 70% of municipal waste and 80% of packaging waste by 2030. The process of obtaining information and use of that information in the model presented in this paper could then serve as a guide for acquiring information on the state of the circular economy. The final résumé, supported by explicit research, is that the best thing about the circular economy is the long-term economic profit it offers to enterprises and also the benefit it provides to the environment and thus the people of this planet.

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