Professor Marian STOICA, PhD
E-mail: marians@ase.ro
Department of Economic Informatics and Cybernetics
Bucharest University of Economic Studies, Romania

Professor Marinela MIRCEA, PhD (corresponding author)
E-mail: mmircea@ase.ro
Department of Economic Informatics and Cybernetics
Bucharest University of Economic Studies, Romania

Ec. Ion-Dănuț LIXANDRU, PhD
E-mail: danut.lixandru@mk.ase.ro
Department of Economic Informatics and Cybernetics
Bucharest University of Economic Studies, Romania

A CYBER DIMENSION TO THE CIRCULAR ECONOMY – THE MODEL OF EXTERNAL COMPLEMENTARITY IN CONSUMER BEHAVIOUR

Abstract*. The dizzying speed of the development of global society in the 3rd millennium, through the spectacular growth of the information technology industry, is beginning to experience more and more brakes. Among these, the natural resource crisis, fuelled by various other crises, primarily human-induced, should be highlighted. Characterised by over-consumption and the tendency to deplete production resources, the traditional economic model is based on the produce-consume-throw-away principle. In contrast, the circular economy is a production and consumption model that involves extending the life cycle of products while acting as an intermediary ecosystem for the interaction between nature and society. Based on the premise that consumer input is significant in the circular economy, this paper proposes a model inspired by the cybernetic principle of external complementarity and applied to consumer behaviour, in which consumers can mitigate impacts on nature. Thus, based on the data research in the model, using a factor reduction analysis, the most important components in the process of creating new production resources were determined. Using a systems approach, the study highlights the link between the determinants of consumer behaviour in relation to the natural environment, with the aim of helping manufacturing organisations to understand how to move from a linear to a circular economy.*

Keywords*: circular economy, consumer behaviour, external complementarity, system, cyber dimension*

JEL Classification: A13, C52, P51, Q57

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1. Introduction

The concept of the circular economy, which emerged almost 60 years ago, is based on the idea of our planet's finite and finite resources (Boulding, 1966). The context of today's world, where the level of resources necessary in the production process is reaching worrying levels, makes the circular economy a restorative and regenerative concept, with the aim of keeping goods, components, and materials at their maximum use and value at all times. It replaces the idea of end-of-life (physical/moral wear and tear) with restoration, shifts to the use of renewable energy, eliminates the use of harmful chemicals, and aims to eliminate waste by improving the quality of materials, products, systems, and business models.

As the Organisation for Economic Co-operation and Development (OECD) reports, the places where people live and work, where they consume and produce goods and services play an important role in the transition to a circular economy. In the demographic context, the global population is expected to exceed 9 billion people by 2050 and cities will be home to more than 55% of this population (OECD, 2020). Cities are currently responsible for about two-thirds of global energy demand, generate up to 50% of solid waste, and are responsible for 70% of greenhouse gas emissions. A study (Statista, 2019) shows that the populations of North America and Europe will remain the world's largest producers of waste, with 2.5 and 1.4 kg/day of waste per capita, respectively, by 2050. A report (Circle Economy, 2022) outlines 21 possible interventions in different sectors that can bring the circular economy to an optimal stage for better stewardship of the planet's resources. These include the efficient design of ITC equipment, appliances, consumer products, homes, vehicles, and sustainable ways of preparing food. This efficient design includes the use of recyclable production materials.

The issues are becoming increasingly serious in the context of Industry 5.0, where artificial intelligence (AI) is the key to economic development through automation and robotisation. The AI industry is a significant resource consumer, which can interact significantly with a sustainable circular economy. The cybernetic dimension of this circular economy is primarily evident at the intersection with Industry 5.0, through the obvious or intuitive manifestation of the cybernetic economic system legacies. Thus, R. Ashby's law of necessary variety, N. Wiener's law of inverse connection (feedback), the principle of external complementarity on the basis of which we are building the analysis model, H. Haken's emergence principle, respectively, the principle of negative entropy (here we should mention the contributions of the Romanian researchers Șt. Odobleja – see consonant psychology and O. Onicescu– see probability theory and information energy) have specific manifestations in the technological and functional aspects of the ecosystem represented by the artificial intelligence industry and the circular economy (Stoica et al., 2022).

The circular economy has definitely gained prominence in recent years as a sustainable alternative to the traditional economy. The traditional economy is unsustainable in the long term because it is based on the continued exploitation of finite resources that will eventually run out. The circular economy, on the other hand, is based on the notion of using resources efficiently and keeping them in use for as long as possible. In this context, based on the cybernetic principle of external complementarity, a systemic analysis of the influence of consumers on this economy, perceived in its cybernetic dimension, is necessary.

Built on the anthropocentric paradigm, the success of the circular economy perceived as a model of production and consumption in the key produce-use-recycle depends to the greatest extent on its main actor: the person, the individual. Consequently, an analysis of the behaviour of individuals in their relationship with the circular economy through a systemic, cybernetic approach is a challenge. The encapsulation of the individual's attitude in relation to the principles of the circular economy gives the latter its behavioural dimension, which is clearly embodied in the behavioural economy (Chiriță et al., 2021). This paper analyses the relationship between consumer behaviour perceived in its external complementarity and the circular economy seen in its cybernetic dimension. For this purpose, an analysis model developed on a theoretical and practical research through a survey will be developed. The structure of the paper first addresses the current state of knowledge in the field of circular economy and its relation to consumer behaviour, continues with the presentation of the research methodology, hypotheses, and research coordinates, the development of the analysis model, data analysis, and interpretation of the results. Finally, the main conclusions are drawn and future research directions are identified.

2. Current state

The aim of a circular economy is to help human civilisation move toward a system of production and consumption that reduces negative environmental impacts, thereby protecting or restoring planetary boundaries. This alternative paradigm has recently gained widespread awareness and has attracted high interest at all levels of society due to the inherent economic and environmental problems raised by the existing economic system (Tonelli & Cristoni, 2019). Obviously, these problems have also been projected onto manufacturing organisations and, more importantly, their consumers. Guzzo, Rodrigues and Mascarenhas (2021) point out that the productive sector is one that requires the transition to the circular economy, as it is extremely important because it facilitates daily tasks, improves living and working conditions, and stimulates communication. Thus, the growth in consumption of products in general is influenced by the growing global population, the emerging middle class, and the increasing degree of urbanisation.

Tan and Cha (2021) argue for a better, more compassionate, and environmentally friendly lifestyle. These are known as latent desires because they are subconscious, pervasive, and fundamental in each of us. Despite having these hidden desires, our decisions to pursue and satisfy them are often overridden by explicit counter-signals from the surrounding world, which encourage fast-paced consumption.

According to Camacho-Otero et al. (2020), consumption is divided into six stages. The first stage is acquisition, which is the process by which consumers obtain the items to be consumed. It is followed by the use stage, which refers not only to the physical deterioration of items, but also to the production of meaning. Another key notion within the use stage is appropriation, which is the process by which consumers integrate the purchased goods into their daily lives.

Then there is appreciation, which occurs when individuals respect such artefacts in their home. Devaluation occurs when such goods lose their significance and, as a result, their relevance to the customer. They then separate themselves from them, driving them out of the area of their own household. The divestment ends the consumptive use stage and moves to the disposal stage. At the same time, also Camacho-Otero et al. (2020) argues that in a circular economy, in the purchasing stage, customers can purchase either *circulated items* (second-hand, reconditioned, recycled) or the *function of the product*. First, users should use such items over long periods of time to reduce the need for new materials.

The second type of purchase, the function of the product, requires users to use the product for a limited period of time to avoid creating a too strong bond with it. However, a cautious link must be created so that the product is in excellent condition for the next user. These two types of purchase have ramifications throughout the disposal phase. Final disposition should allow the product to re-enter the system in both situations. Compared to linear consumption, these qualities could make circular consumption difficult. All these characteristics establish both the extent of the direct interaction of the circular economy with the environment (customers, users) and the extent to which it is impossible to operate independently. This once again highlights the principle of external complementarity in the cybernetic system represented by the circular economy.

Mavropoulos and Nilsen (2020) talk about Industry 4.0 and specify that with each industrial revolution new items and methods of production, distribution, and use emerge. This implies that new resources and raw materials are exploited and new forms of waste are generated. But putting research and innovation specifically at the service of the transition to a sustainable, human-centred, and resilient industry will lead to a new concept: Industry 5.0 (DGRI, 2022). Perhaps looking ahead, Industry 5.0, or the artificial intelligence industry, and the circular economy are two of the most important systemic developments today. Both are based on the concept of more efficient use of resources and both have the potential to increase the sustainability of production. The circular economy is still in its infancy, and much work is needed to enable the transition to a fully circular economy. However, circular economy ideas offer a viable and sustainable alternative to the current linear economy. Gheewala and Silalertruska (2021) believe that the circular economy goes beyond reducing resource use and environmental pollution; it focuses more on extending the life of existing items through reuse, repair, refurbishment, and remanufacturing. Of course, recycling materials is probably the last in the hierarchy of circularity, as extending the life of products through the methods listed maintains the value of the resources and energy involved in making the product.

Özkan and Yücel (2020) reveal that the mass production model, which started with the industrial revolution, is defined as linear due to the unidirectional flow of resources used and lost as waste. Subsequently, during the 20th century, the economy expanded rapidly due to corporate methods that required more consumption to generate more. This gave rise to the concept of planned obsolescence, which is the production model of this economic system, which operates in a linear fashion according to the take, produce, and throw away perspective. Planned obsolescence, which aims to allow consumers to buy more new things in a shorter time, has also led to overuse of resources.

Also, Özkan and Yücel (2020) find that states and international organisations have built a new economic and legal structure for a sustainable environment, businesses have changed their production and marketing tactics, and consumers have been guided toward environmentally sensitive choices in all their consumption activities.

Mohammdi, Singh and Habib (2021) mention that a good waste management strategy should include developing of a plan to optimise the reduction of overall product consumption, reuse, and recycling of end-of-life items in an economically and environmentally sustainable way. This strategy should include action plans for the development of policies, financial systems, technology, and skills. Here, as can be seen from the above-mentioned understandings, the consumer has a number of roles to play in the circular economy. They must adapt their needs to a pro-consumption reduction, re-use, and recycling of used products.

Brooks and Wilson (2015) consider that *reducing consumption* is a choice rather than a necessity, and therefore it is quite difficult for modern-day consumers to adopt such a position unless they are constrained by a particular context. Of course, there are ways in which consumers can accept consumption reduction in an active and deliberate way. Voicu (2021) lists some marketing activities that could help reduce consumption, in terms of marketing mix, or in terms of changing perceptions of consumption or even with downshifting. However, it is becoming extremely difficult to adopt reduction policies in today's abundant but easy production environment.

Cruz-Cárdenas, Guadalupe-Lanas and Velín-Fárez (2019) note, concerning the *reuse of products*, that companies play a minor role and that the reuse of a product is influenced by a number of factors and is based on the value that the consumer can attribute to this product. In a simple sense, the consumer reuses the product if it has given him satisfaction with its previous use (Tseng and Wang, 2013), but practice shows us that this reuse is quite limited for many products.

Shevchenko, Laitala and Danko (2019) expose, through their research, that *recycling* differs quite a lot depending on the regions to which consumers belong:

either when they have a high level of awareness and sensitisation, or when they have an infrastructure that provides them with sufficient recycling conditions, or when they receive a remuneration or even realise that they can have a significant contribution to environmental protection. Williams et al. (2018) point to the idea that packaging design has a very strong influence on whether an act of recycling is achieved.

In view of these three attributes of the consumer (*reduce consumption*, *reuse*, *and recycle*), it becomes necessary to assess their impact on the waste of such products, which according to the circular economy concept can become a resource for the design of new products. Research and definition of a behavioural model that can reduce waste and reintroduce a large part of the materials already used in the economic cycle is therefore needed.

3. Research methodology

The circular economy is often seen as an answer to the problems of the traditional linear economy, such as resource depletion, waste production, and environmental pollution. However, the circular economy is not just an alternative to the linear economy, but a completely different way of thinking about the economy and consumers' relationship with the environment. These aspects make awareness of the process of reducing consumption, reusing, and recycling products indispensable for any manufacturing organisation.

The aim of this study is to develop a model based on practical and theoretical research on the phenomenon of waste production and to examine various possibilities of transforming waste into new production resources. The model is built on the characteristic of external complementarity of the production process in the circular economy.

Regarding the research objectives, the research focuses on the following:

- Testing the grouping of variables;
- Assessing causal relationships between model variables;
- Determining the amount of resources/material losses that respondents generate, according to the behaviour adopted.

Research hypotheses:

For the development of a relevant model, a pretest in order to identify the mode of action of the variables can be considered relevant; therefore, an assumption without which the current research approach cannot proceed is:

- H0 – the variables act grouped according to the three types of consumer behaviour/attributes associated.

According to a study by Zhang and Kim (2021), product reuse has satisfaction as its foundation, which is influenced by variables such as information quality, service support, product quality, and product delivery quality. As a result, the following hypotheses are distinguished:

- H1-1 – information quality has a positive impact on consumer satisfaction;
- H1-2 – quality of service support has a positive impact on consumer satisfaction;
- H1-3 – product quality has a positive impact on consumer satisfaction;
- H1-4 – delivery quality has a positive impact on consumer satisfaction;
- H1-5 – consumer satisfaction has a positive impact on reuse intention.

As Kerber et al. (2021) show, three factors act directly on the demand for a product, namely availability, perceived quality, and information about it. In the light of the aforementioned premise, a different set of assumptions can be distinguished, applicable to this case, as follows:

- H2-1 – availability has a positive impact on consumption reduction;
- H2-2 – perceived quality has a positive impact on reducing consumption;
- H2-3 – product information has a positive impact on reducing consumption.

Liu et al. (2019) demonstrate that recycling is directly dependent on two factors, namely the consumer's attitude toward recycling (influenced by their assumed responsibility toward the environment and their own capabilities translated by recycling opportunities) and perceived behavioural control (influenced by the convenience of the recycling process). Accordingly, we can construct the following set of hypotheses:

- H3-1 – environmental responsibility has a positive impact on attitudes toward recycling;
- H3-2 – one's own capabilities have a positive impact on attitude toward recycling;
- H3-3 – convenience of the recycling process has a positive impact on perceived behavioural control;
- H3-4 – attitude toward recycling has a positive impact on the recycling process;
- H3-5 – control of perceived behaviour has a positive impact on the recycling process.

As we have observed, the three behaviours that consumers can adopt are closely related to the possibility of wasting or not wasting products, thus the following hypotheses can be distinguished:

- H4-1 – reuse has a positive impact on the creation of new resources;
- H4-2 – reducing consumption has a positive impact on the creation of new resources;
- H4-3 – recycling has a positive impact on the creation of new resources.

Research coordinates:

Given the resources and the objective of the study, the sampling scheme is a simple random one, with respondents randomly chosen from social network discussion groups with different interests. In terms of research mode, a questionnaire was developed and distributed online from 19-26 August 2022, with three sets of questions aligned to the research hypotheses, two demographic questions, and one concerning the amount of waste respondents produce. Using the Cochran (1977) formula, the sample size was determined as follows:

$$n_0 = \frac{Z^2 \cdot p \cdot q}{e^2} = \frac{(1.96)^2 \cdot 0.5 \cdot 0.5}{0.05^2} = 385 \quad (1)$$

where: *e* is the margin of error, *p* is the (estimated) proportion of the population with the attribute in question, *q* is 1 - p, and *Z* is the number of standard deviations.

Given the resources of the research and the limited possibilities of reaching a larger population, 340 questionnaires were completed. Of these, 204 respondents were female and 136 were male. In terms of their age, they fall into the following ranges: under 25 years - 164 people; 25-34 years - 68 people; 35-44 years - 20 people; 45-54 years - 36 people; 55-64 years - 36 people; over 64 years - 16 people.

The questionnaire is based on the research items mentioned in Table 1, where we can also see the coding of the variables. All the questions, except the two demographic ones mentioned above, were constructed using the Likert scale, with individuals having the possibility to express the extent to which they agree with the statements made. The Likert scale was constructed with 5 points, where 1 means total disagreement and 5 means total agreement. The same scale was used for the last item, where the respondents could choose the following values: 1 - <= 2 kg.; 2 - 3-4 kg.; 3 - 5-6 kg.; 4 - 7-8 kg.; 5 - > 8 kg. SPSS and WarpPLS tools were used for data analysis.

Table 1. Description of variables

Question set	Crt. no.	Item	Item Codification	Latent variable
1	1	I find information quickly about products I want to buy.	Qinfo1	Quality of information (**QInfo**)
	2	Information is constantly updated by traders.	Qinfo2	
	3	The staff at the store I order from (physical/online) is friendly.	Qservice1	Quality of services (**Qservice**)
	4	The staff at the store I order from (physical/online) recommend products.	Qservice2	
	5	The products they use are reliable.	Qprod1	Product quality (**Qprod**)
	6	The products I use are in line with my needs.	Qprod2	
	7	The shop (physical/online) I buy from delivers on time.	Qdistrib1	Distribution quality (**Qdistrib**)
	8	The attitude of the team who deliver to me is friendly.	Qdistrib2	
	9	I am satisfied with the products I use.	Satisf	Satisfaction felt (**Satisf**)

Question set	Crt. no.	Item	Item Codification	Latent variable
	10	I recommend used products to others I know.	Reuse	Product reuse (**Reuse**)
2	11	The store (online/physical) I usually buy from has the product available when I need it.	Availabi1	Product availability (**Availabi**)
	12	I quickly find the product I need at domestic retailers.	Availabi2	
	13	I buy products whose brand I am familiar with.	PercVal1	Perceived value of the product **(PercVal)**
	14	A known product on the market gives me more confidence to buy it.	PercVal2	
	15	If I don't know enough about the product I need, I don't buy it.	Info1	Information **(Info)**
	16	If an acquaintance gives me information about a product, I have more confidence to buy it.	Info2	
	17	In the last 12 months I have bought many products.	Reduce	Consumption reduction behaviour (**Reduce**)
3	18	I believe that the products I buy are harmful to the environment.	Resp1	Environmental responsibility (**Resp**)
	19	I only use products made of recyclable materials.	Resp2	
	20	I know how to recycle products.	SAbility1	Personal skills (**SAbility**)
	21	I have the ability to take the products to the collection point.	SAbility2	
	22	I find it convenient to recycle used products.	Conven1	Convenience of recycling (**Conven**)
	23	I have waste collection centres near my home.	Conven2	
	24	I believe that recycling helps the environment.	Attitude	Attitude toward recycling (**Attitude**)
	25	I can handle my own product recycling.	PBC	Personal behaviour control (**PBC)**
	26	I recycle products that I no longer use.	Recycle	Recycling (**Recycle**)
	27	In the last 12 months, we have thrown away or recycled the following amount of products:	Resource	Possible resources (**Resource)**

4. Data Analysis and Results Interpretation

In order to achieve the first research goal, we conducted a factor reduction analysis using SPSS. To compare the observed correlation coefficient sizes with the partial correlation coefficient sizes, we used the Kaiser-Meyer-Olkin index (0.724). The Bartlett sphericity test value (4949.39, Sig=0.000) is modest enough to reject the hypothesis that the variables are uncorrelated, implying that the data are strongly related. These values suggest, as can be seen in Table 2, the presence of one or more common factors, which encourages the use of a factor reduction process.

Table 2. KMO Coefficient and Sphericity Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.724
Bartlett's Test of Sphericity	Approx. Chi-Square	4949.395
	df	351
	Sig.	.000

Table 3, in which we see the total variance explained, provides the first information specific to factor analysis. The principal component analysis (PCA) approach was used to obtain a total of 27 principal components or factors. Table 3 shows that only the first eight components meet the selection condition (eigenvalues>=1), which means that eight components mostly (70.140%) describe the behaviour of the studied. As can be seen, the first of the eight components undergoes a negative change. Thus, from the degree of influence of 26.577%, it redistributes to the remaining components up to 16.777%. The other components undergo positive changes.

Table 3. Total variance explained

Total Variance Explained									
Compo-nent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.176	26.577	26.577	7.176	26.577	26.577	4.530	16.777	16.777
2	3.483	12.900	39.478	3.483	12.900	39.478	3.743	13.864	30.641
3	1.746	6.466	45.944	1.746	6.466	45.944	2.421	8.967	39.608
4	1.577	5.842	51.786	1.577	5.842	51.786	2.048	7.586	47.195
5	1.531	5.670	57.456	1.531	5.670	57.456	1.726	6.392	53.587
6	1.245	4.612	62.068	1.245	4.612	62.068	1.613	5.975	59.562
7	1.135	4.202	66.271	1.135	4.202	66.271	1.460	5.406	64.967
8	1.045	3.869	70.140	1.045	3.869	70.140	1.397	5.172	70.140
9	.953	3.529	73.669						
10	.812	3.008	76.677						
11	.793	2.937	79.614						
12	.656	2.431	82.045						
13	.642	2.379	84.424						
14	.558	2.067	86.491						
15	.513	1.899	88.390						
16	.449	1.662	90.052						
17	.440	1.628	91.680						
18	.388	1.438	93.117						
19	.320	1.186	94.303						

Total Variance Explained									
Compo-nent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
20	.288	1.065	95.368						
21	.257	.951	96.319						
22	.232	.858	97.177						
23	.208	.770	97.947						
24	.197	.729	98.676						
25	.162	.602	99.278						
26	.115	.427	99.705						
27	.080	.295	100.000						
Extraction Method: Principal Component Analysis.									

The eigenvalues for all the principal components obtained using the PCA technique are presented in a sequence of primary factors in Figure 1. The number of items is set so that the levels in the graph reflect a linear decreasing trend. Since the eigenvalues indicate a linear decreasing trend, Figure 1 shows the presence of an eight-factor solution.

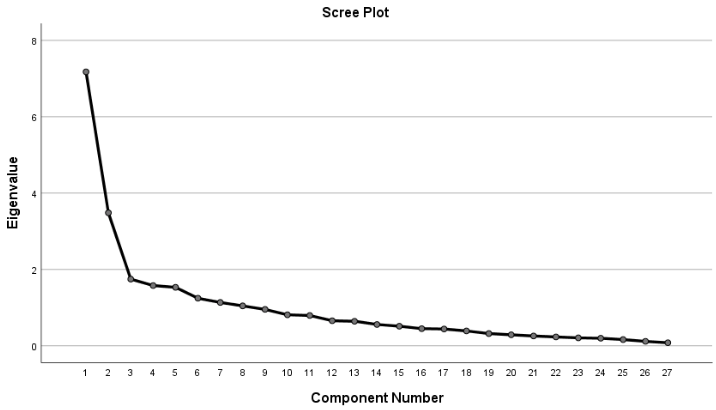

Figure 1. Components chart after rotation

Three distinct clusters can be seen in the overall grouping of variables in Figure 2 based on the degree of correlation of the components to which they belong. As we can see in the right part of the picture, one of the groupings contains mostly variables related to the respondents' usage behaviour, and in the upper part of the graph we can observe variables of recycling acceptance behaviour. On the left side we can distinguish a mix of variables related to consumption reduction and reuse.

Table 4 shows the distribution of components by rotation. Thus, the first component with the highest degree of influence (16.777%) is made up of the variables: attitude, service support, information quality, product quality, environmental responsibility, recycling convenience, reuse, and product knowledge. The second component is made up of variables such as own capabilities, recycling, convenience of recycling and environmental responsibility. The third component contains the variables product quality, environmental responsibility, satisfaction, reuse, and product availability. The fourth component consists of the variables service support, environmental responsibility, product availability, product perception, and own capabilities.

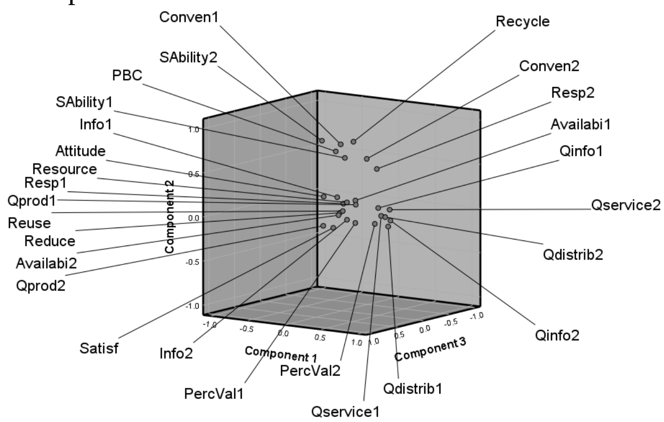

Figure 2. Distribution of components in space

Component number five contains variables such as own capabilities, product information, and perceived value. Component six is covered by the variables: quality of service, environmental responsibility, product information, and consumption reduction. The seventh component, with an influence on respondents' behaviour of 5.406%, consists of the variables: convenience of recycling, resources/waste and consumption reduction. The last component is defined by the variables: product perception, attitude, and consumption reduction.

Table 4. Rotated Component Matrix

Rotated Component Matrix[a]								
	Component							
	1	2	3	4	5	6	7	8
Qdistrib2	.775							
Qservice2	.747					.309		
Qinfo2	.744							
Qdistrib1	.740							
Qservice1	.717							
Qinfo1	.608							
Qprod1	.465		.391					
SAbility2		.814			.305			
Recycle		.807						
Conven1		.774					.338	
PBC		.687		.318				

Rotated Component Matrix[a]								
	Component							
	1	2	3	4	5	6	7	8
SAbility1		.654						
Conven2	.362	.651						
Resp2		.475	-.319			.415		
Qprod2			.782					
Satisf	.409		.750					
Reuse	.480		.666					
Availabi1				.791				
Availabi2			.395	.719				
Info1					.759			
PercVal1				.362	.590			.413
PercVal2	.438			.348	.563			
Info2						.798		
Resp1				.349		.571		
Resource							.768	
Attitude								.767
Reduce						.403	.506	-.513
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.								
a. Rotation converged in 12 iterations.								

According to this analysis and in line with the first objective of the research, hypothesis H0 can be accepted, according to which the variables included in the research act grouped according to the attributes a consumer may have in terms of reducing product waste or creating new resources.

For the second objective of the research, the model created using all the research variables is subjected to analysis, and links are created, as Zhang and Kim (2021); Kerber et al. (2021) and Liu et al. (2019) showed. Thus, from the 27 items or research variables, the model shown in Figure 3 was created.

The results of the research on the relationship between variables are as follows:

- H1-1 – quality of information has a positive impact on consumer satisfaction – (β= -0.003, p-value = 0.48) – rejected;
- H1-2 – quality of service support has a positive impact on consumer satisfaction (β = 0.04, p-value = 0.22) – rejected;
- H1-3 – product quality has a positive impact on consumer satisfaction (β= 0.51, p-value < 0.001) – accepted;
- H1-4 – delivery quality has a positive impact on consumer satisfaction (β= 0.29, p-value < 0.001) – accepted;
- H1-5 – consumer satisfaction has a positive impact on reuse intention (β= 0.73, p-value < 0.001) – accepted;
- H2-1 – availability has a positive impact on consumption reduction (β= 0.25, p-value < 0.001) – accepted;

- H2-2 – perceived quality has a positive impact on consumption reduction (β= 0.9, p-value = 0.04) – accepted;
- H2-3 – product information has a positive impact on consumption reduction (β= 0.22, p-value < 0.001) – accepted;
- H3-1 – environmental responsibility has a positive impact on attitude toward recycling (β= -0.19, p-value < 0.001) – accepted;
- H3-2 – one's own capabilities have a positive impact on attitude toward recycling (β= 0.26, p-value < 0.001) – accepted;
- H3-3 – convenience of the recycling process has a positive impact on perceived behavioural control (β= 0.52, p-value < 0.001) – accepted;
- H3-4 – attitude toward recycling has a positive impact on the recycling process (β= 0.10, p-value = 0.03) – accepted;
- H3-5 – perceived behaviour control has a positive impact on the recycling process (β= 0.59, p-value < 0.001) – accepted;
- H4-1 – reuse has a positive impact on the creation of new resources (β= 0.15, p-value < 0.001) – accepted;
- H4-2 – reducing consumption has a positive impact on the creation of new resources (β = 0.15, p-value < 0.001) – accepted;
- H4-3 – recycling has a positive impact on the creation of new resources (β= 0.18, p-value < 0.001) – accepted.

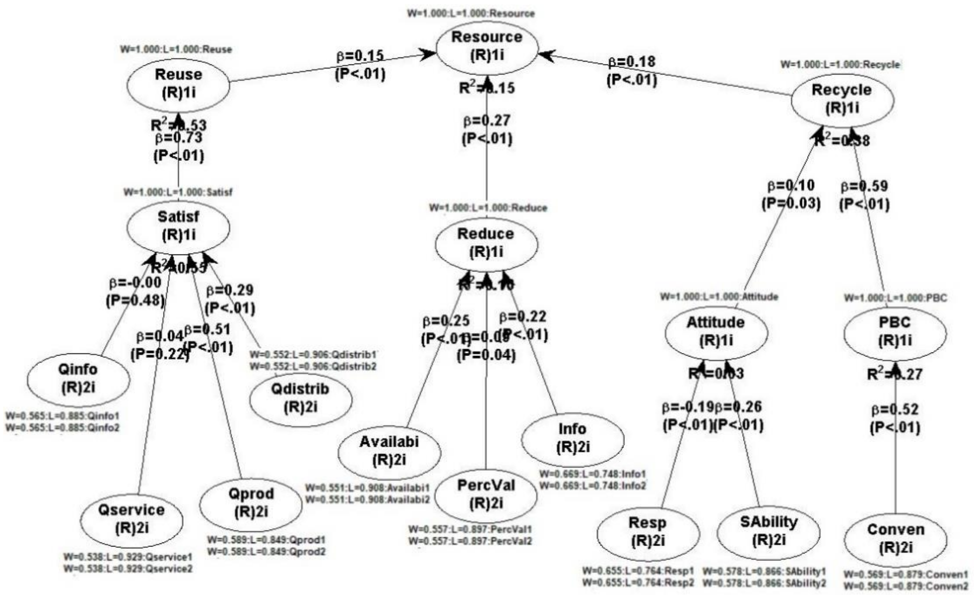

Figure 3. Model of new resource generation in the circular economy

Similarly, to test the validity of the model, the indicators in Table 5 that demonstrate that it meets the acceptance rules are taken into consideration.

Table 5. Model quality indicators

Average path coefficient (APC)=0.274	P<0.001
Average R-squared (ARS)=0.297	P<0.001
Average adjusted R-squared (AARS)=0.292	P<0.001
Average block VIF (AVIF)=1.292	Acceptable if <= 5, ideal <= 3.3
Average full collinearity VIF (AFVIF)=2.108	Acceptable if <= 5, ideal <= 3.3
Tenenhaus GoF (GoF)=0.503	Small >= 0.1, medium >= 0.25, High >= 0.36
Simpson's paradox ratio (SPR)=0.875	Acceptable if >= 0.7, ideal = 1
R-squared contribution ratio (RSCR)=0.985	Acceptable if >= 0.9, ideal = 1
Statistical suppression ratio (SSR)=1.000	Acceptable if >= 0.7
Nonlinear bivariate causality direction ratio (NLBCDR)=0.750	Acceptable if >= 0.7

In order to achieve the last objective of the research, item 27 of the questionnaire was analysed and the coding of the dependent variable was based on the following values: 1 - <= 2 kg, 2 - 3-4 kg, 3 - 5-6 kg, 4 - 7-8 kg, 5 - > 8 kg. After calculating the averages for each type of behaviour, the results you can see below are obtained, and, according to these findings, the greatest amount of resources is generated by respondents who engage in consumption-reducing behaviour.

- Reuse: (1.00+1.00+1.82+1.95)/4=1.44;
- Reduction of consumption: (1.00+1.53+1.79+1.46+2.39)/5=1.63;
- Recycling: (1.33+1.21+2.33+1.71+2.13)/5=1.74.

5. Conclusions, limitations, and further research

Based on the model developed, a practical approach to consumer behaviour can be observed. This model presents in a logical order the possibilities that the consumer can address in an attempt to become a responsible participant in the circular economy. According to the results, the model shows that the first option that the consumer can address, i.e., *reuse of products*, is positively influenced by consumer satisfaction. Thus, the producing organisation must clearly take responsibility for creating a product in line with the customer's expectations in terms of quality and distribution.

The second variant, represented by the *reduction in consumption*, is positively influenced by the availability of the product, the value that the consumer attributes to it, and the information about the product. Although from an economic point of view this seems to be an option that is not at all beneficial to the organisation, it only involves reducing the use of those products that are harmful. In other words, according to the logic of the model, if the level of availability of environmentally friendly products, their perceived value, and information about them increases, the consumption of harmful products will decrease.

The last possible variant brings *recycling behaviour* to the fore, which is influenced by the attitude and control of the consumer's personal behaviour. The first of these is determined by environmental responsibility and the consumer's ability to respond positively to such behaviour. The second (PBC) is the consequence of the convenience that the consumer has when he/she wants to recycle. If these three options are controlled by the organisation, they can have positive consequences on natural resources and, obviously, on the loss of production materials.

Looking at it from an institutional approach, valid for both manufacturing companies and other organisations involved in the development of the circular economy, the paper offers the possibility to identify the easiest way to get consumers to adopt a certain behaviour. The cybernetic approach to the main aspects of consumer behaviour in relation to the circular economy makes the analysis and modelling of this ecosystem concrete and feasible. The external complementarity of the consumer-circular economy duality reduces the seemingly obvious abstraction of this cyber system and can lay the foundations for a successful implementation of the new production and consumption model.

In this context, a future approach will aim at an extension of the variables that can influence the types of behaviours and then an analysis of the sensitivity of these factors, in order to develop a mathematical model for knowing the probabilities of generating new resources in order to reintroduce them into the economic cycle.

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