Environmental Activities of Enterprises and Zero Waste Logistic Systems

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Abstract: The increase in consumption and production has given a boost to the amount of generated waste. It is counteracted by the field of management which continues to produce new concepts for the reduction of waste and its environmental impact. One of them is the zero waste logistics concept. The purpose of the article is to present the functioning of zero waste logistics systems as a tool for the realization of reverse flows in building closed economic cycles. The article examines the effects of the implementation of the zero waste concept in enterprises. To this end, a multidimensional analysis of data on the processes realized through zero waste logistics systems in European countries in the years 2010, 2012 and 2014 has been carried out.

Keywords: waste, waste treatment, environmental activities of enterprises, zero waste logistics systems

1 Introduction

The increased threat to the environment through waste fueled the emergence of the concept of zero waste. The concept is to encourage sustainable attitudes in both producers and consumers, which can help reduce expenses and build a better world [1]. In the subject literature there is a wide and multithreaded discussion on the premises of the concept [2, 3, 4, 5, 6, 7]. Proecological behaviours of all entities in the flows of resources from supplier to producer determine the directions of the development of zero waste logistic systems.

Proecological activity of enterprises leads to the minimization of the consumoption of material and energy resources and to the creation of new outlet markets. Resources can be managed in new ways and the life cycle of products and services as well as their scope and their contribution to the social welfare can be increased [8]. Enterprises often indicate that the reduction of transport and production costs with the simultaneous minimization of environmental impact of their activity is one of their main goals [9], which is realized also by the creation of closed economic cycles. This means that businesses actively participate in the

realization of the principles of the zero waste concept, and constitute an element of a zero waste logistic system through building supply chains. Therefore, an analysis of the effects of proecological activity of enterprises in the context of zero waste logistic systems seems well-founded. And so the goal of the article is to evaluate the effects of the proecological activity of enterprises as well as the stability of these effects in the 28 countries of the European Union.

2 Pro-environmental enterprises – towards zero waste logistic systems

Enterprises generate waste, but at the same time they carry out activities to reintroduce waste materials into the economic system, mainly through the processes of recovery and recycling, creating zero waste strategies [10]. The promotion of these processes is connected with the concept of zero waste. [11, 12]. In view of the fact that the production of a given product is often accompanied by numerous secondary processes, the creation of zero waste logistic systems is reasonable. The implementation and realization of the concept of zero waste is only possible through the coordination and integration of the activities carried out by all members of a supply chain. One could even go as far as to say that although enterprises perform their proecological activities to merely adhere to market standards, they are actually the basic pillar of waste logistic systems. Enterprises which launch pro-environmental products reduce the environmental impact of production processes, carry out the recovery and recycling of waste. Therefore, it is their proecological behaviour that drives the creation of zero waste logistic systems. The proecological activities of businesses which play an important role in the transformation of the traditional economy into a zero waste economy include:

- manufacturing of Cradle to Cradle certified products,
- using the cleaner production technologies,
- implementation of the Extended Producer Responsibility Programme,
- meeting assumed recovery and recycling rates,
- reduction of primary resources and energy consumption,
- making products ready for recycling,
- implementation of zero landfill concept.

Table 1 shows the directions of the proecological activity of small and medium sized enterprises in individual countries of the EU in 2017. Fundamental to that activity are efforts towards the reduction of waste and efficient management of energy, materials and water. Those last three activities lead directly to the reduction of generated waste. The analysis of the data in table 1 makes it clear that the proecological activity of businesses is connected with the geography of Europe. The percentage of enterprises realizing environmental goals in the

countries of Western and Northern Europe (without the Baltic States) and Southern and Central Europe is much higher than in the countries from other regions of Europe.

Table 1

	Minimising waste	Saving energy	Saving materials	Saving water	Recycling, by reusing material of waste within in the company	Designing products that are easier to maintain, repair or reuse	Selling your scrap material to another company	Using predominantly renewable energy (e.g. including own production through solar panels, etc.)
European Union 28	65	63	57	47	42	25	21	14
Belgium	75	70	61	46	41	25	25	20
Bulgaria	28	36	31	29	17	10	16	4
Czech Republic	64	61	47	43	35	33	29	7
Denmark	49	55	52	40	29	26	26	9
Germany	60	69	57	35	38	24	22	32
Estonia	9	21	15	8	13	5	6	4
Ireland	84	69	58	59	71	26	26	18
Greece	37	52	46	33	30	18	26	13
Spain	65	72	69	55	57	32	20	7
France	83	71	60	68	41	33	18	6
Croatia	64	65	62	50	28	17	27	8
Italy	74	57	52	44	37	23	15	15
Cyprus	29	48	30	27	47	8	15	8
Latvia	35	59	55	44	15	16	10	3
Lithuania	20	42	33	36	7	7	15	4
Luxembourg	57	49	52	31	44	27	25	15
Hungary	40	48	45	40	19	16	21	8
Malta	62	74	34	31	51	15	20	15
Netherlands	65	65	61	32	37	21	26	27
Austria	59	71	52	43	47	31	25	32
Poland	55	57	60	49	24	17	21	4
Portugal	55	75	75	63	66	42	24	9
Romania	31	33	29	23	22	6	12	4
Slovenia	51	47	52	35	33	26	22	16
Slovakia	44	58	43	45	35	14	16	5
Finland	55	51	54	27	31	23	18	14
Sweden	76	57	66	36	62	32	26	35
United Kingdom	82	67	62	56	70	25	29	16

The directions of the proecological activity of small and medium sized enterprises in individual countries of the EU in 2017 (percentage of enterprises). *Source: [13]*

Without a doubt, enterprises should increase their participation in pro-environmental design of products and use of renewable energy sources. But positive tendencies in the behaviour of businesses are observable. A big number of them see the need to reduce waste, not only by disposal activities, but also through a resource efficient economy. Proecological activity of enterprises undoubtedly translates into effects for the natural environment. The undertaken activities pave the way for the zero waste logistic systems where material flows are realized in both directions - from producer to consumer, and back - from consumer to producer.

3 Description of diagnostic variables in the evaluation of the effects of the pro-environmental activity of businesses in the context of a zero waste logistic system

In order to evaluate the effects of the proecological activity of enterprises in the context of zero waste logistic systems, the linear ordering method from the area of multidimensional analysis of data was used. It was assumed that the effects can be expressed by a synthetic variable composed of both positive and negative effects of proecological activities carried out by businesses (or the lack of such activities). The analysis encompassed 28 countries of the European Union. It was assumed that the effects achieved in a given country reflect the activities carried out by enterprises in order to implement circular economy and create zero waste logistic systems. The determination of a synthetic variable allowed to create a ranking of the States of the European Union in terms of the achieved level of effects. It was done in the following steps:

1. A matrix was created. Its elements were the observations of the statistical data observed for the individual countries of the European Union (x_{ij}). The variables in the matrix had the character of both stimulants and destimulants.

   $$X = [x_{ij}] \ (i=1, 2, \ldots, n; j=1, 2, \ldots, m). \quad (1)$$

2. The unitarization of variables was done in order to free the variables from their titre and to unify their values according to the formula:

   $$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}, \ (i=1, 2, \ldots, n; j=1, 2, \ldots, m) \quad (2)$$

   where: n – the number of countries,
   m – the number of variables,
   z_{ij} – standardized value of variable X_j,

$\bar{x}_j$ – arithmetic average of variable X_j,

s_j – standard deviation of variable X_j.

3. Euclidean distances from the benchmark were calculated for the individual objects:

$$d_{i0} = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_{0j})^2} \qquad (i = 1, \ldots, n) \tag{3}$$

$$z_{0j} = \begin{cases} \max\limits_{i} z_{ij} \ \ for\ stimulants \\ \min\limits_{i} z_{ij} \ \ for\ destimulants \end{cases} \tag{4}$$

The process of distance measurement did not take into consideration the weights, which is tantamount to saying that all variables influence the level of the analyzed phenomenon wih equal strength [14].

4. A measure of development for every object was estimated by the formula:

$$m_i = 1 - \frac{d_{i0}}{d_0} \qquad (i = 1, \ldots, n) \tag{5}$$

where:

d_0 – the distance between the pattern and anti-pattern of development:

$$d_0 = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_{\_0j})^2} \qquad (i = 1, \ldots, n) \tag{6}$$

$$z_{\_0j} = \begin{cases} \min\limits_{i} z_{ij} \ \ for\ stimulants \\ \max\limits_{i} z_{ij} \ \ for\ destimulants \end{cases} \tag{7}$$

The measure of development detemrined by the formula (5) has the following characteristics [15]:

1. The higher the level of the examined phenomenon, the higher the value of the development measure.
2. The development measure displays values from the [0, 1] range.

The effects of proecological activities for the countries of the European Union were described by the following set of variables:

1. Circular material use rate (%),
2. Generation of waste without recyclable waste (kilograms per capita),
3. Generation of recyclable waste (kilograms per capita),

4. Recycling rate of all waste excluding major mineral waste (%),
5. Landfill rate of waste excluding major mineral waste (%),
6. Deposit onto or into land (kilograms per capita),
7. Incineration / energy recovery (kilograms per capita).

The use of variables in the form of intensity indicators was to increase their comparability. The data come from the Eurostat database [16]. The variables embody the effects achieved not only by businesses but also households. It was assumed that proecological behaviours in households are spin-offs of such activities carried out by enterprises, especially in the context of zero waste logistic systems. Systemic approach in logistics is based on taking into consideration all entities realizing the flows of resources which include waste materials. Corporate strategies which incorporate reverse flows influence the behaviours of all members of the logistic system in a positive way as they shape their proecological attitudes. The data chosen for the analysis determine the effects achieved by activities in the context of zero waste logistic systems. The variables include stimulants (Circular material use rate, Recycling rate of all waste excluding major mineral waste, and Incineration / energy recovery) and destimulants (Generation of waste without recyclable waste, Generation of recyclable waste, Landfill rate of waste excluding major mineral waste, Deposit onto or into land). The set of stimulants consists of variables which determine the level of effects which are indicative of the reintroduction of waste materials into the economic system. Destimulants are the variables which reveal the negative effects of the activity of enterprises, or in other words, the amount of generated waste and the landfilling rate. Treating the generation of recyclable waste variable as a destimulant in the context of zero waste logistic systems seems plausible because the character of waste in itself does not guarantee that it will be reintroduced into the economic systems, even if requirements in this respect are met. The years 2010, 2012 and 2014 were analysed.

4 Evaluation of the stability of effects of the proecological activity of enterprises in the context of zero waste logistic systems

The analysis of the stability of the effects of proecological activity of enterprises in the context of zero waste logistic systems showed the convergence level of the results of rankings obtained in the procedure explained above. The ranking concordance measure appeared in the form of the Spearman's rank correlation coefficient (r_S) expressed by the relation:

$$r_S = 1 - \frac{6 \cdot \sum_{i=1}^{n} d_i^2}{n \cdot (n^2 - 1)} \quad (8)$$

where:

d_i - difference between the rank of an nth object (country) in the ranking,

n – number of analyzed objects (countries).

The analysis yielded three rankings for the countries of the European Union which helped determine the effectiveness of the proecological activities carried out by enterprises. Table 2 presents the rankings.

Table 2

EU countries	Rank in the year			Measure of development in the year		
	2010	2012	2014	2010	2012	2014
Netherlands	1	1	1	0,6001	0,6582	0,7978
Denmark	2	2	2	0,5727	0,5783	0,6511
Germany	3	4	3	0,5411	0,5641	0,6462
Belgium	4	3	11	0,5239	0,5700	0,5464
Sweden	5	9	15	0,5190	0,5083	0,5063
France	6	5	4	0,5134	0,5345	0,6391
Poland	7	11	6	0,4877	0,4958	0,6090
Italy	8	8	5	0,4825	0,5190	0,6360
United Kingdom	9	10	8	0,4804	0,4984	0,5755
Austria	10	6	7	0,4694	0,5328	0,5876
Slovenia	11	7	10	0,4501	0,5231	0,5663
Czech Republic	12	12	12	0,4335	0,4741	0,5454
Spain	13	14	14	0,4266	0,4610	0,5094
Luxembourg	14	13	9	0,4160	0,4699	0,5677
Portugal	15	15	20	0,4091	0,4359	0,4619
Lithuania	16	16	16	0,4043	0,4240	0,4900
Hungary	17	19	17	0,3804	0,4131	0,4820
Slovakia	18	20	21	0,3767	0,4036	0,4568
Latvia	19	17	13	0,3507	0,4230	0,5117
Cyprus	20	21	23	0,3488	0,4032	0,4172
Finland	21	18	25	0,3484	0,4164	0,3789
Ireland	22	22	18	0,3442	0,3991	0,4792
Croatia	23	23	19	0,3253	0,3817	0,4737
Romania	24	26	24	0,3162	0,3245	0,3841
Malta	25	25	22	0,3046	0,3540	0,4323
Estonia	26	24	26	0,2879	0,3686	0,3092
Greece	27	27	27	0,2657	0,2780	0,2806
Bulgaria	28	28	28	0,1436	0,1199	0,1113

Results of linear classification – rank and measure of development of the European Union countries according to the effects of proecological activities carried out by enterprises in the years 2010, 2012 and 2014. *Source: Own elaboration based on Eurostat database*

The analysis of the value of the synthetic measure shows that the top ranks in the analyzed years were occupied by the Netherlands, Denmark and Germany. Regardless of the year, the Netherlands always appeared on the top position and Denmark always came second. Bottom places in the ranking belonged to Bulgaria (which was ranked last in every year) and Greece (which was always one but last). The analysis of the development measures shows that they were higher in 2014 than in the previous years (especially for the countries ranked on top positions) which means the countries improved their results in terms of the effectiveness of proecological activity of businesses. The development measure for the Netherlands in 2014 was as high as 0,7978 which is enough to see this country as the benchmark for the others.

The biggest variation in the effects of proecological activity of enterprises in the analyzed years was observed in the following countries: Belgium, Sweden, Poland, Austria and Italy. Belgium, which was ranked high in 2010 and 2012 (fourth and third position respectively), dropped to the 11th position in 2014. Also Sweden was gradually losing its position - from the 5th place in 2010 to the 15th in 2014. Positive changes were observed in Italy which was ranked 8th in 2010 and 2012, but 5th in 2014. Austria also improved the results in 2014 compared to 2010. Although Poland in 2012 dropped by as many as four positions in comparison to 2010, in 2014 it improved significantly climbing to the 6th position.

The analysis of the stability of effects of proecological activity of enterprises observed in individual countries showed if there exist similarities in the ranking of positions for every pair of analyzed periods. The values of the Spearman's rank correlation coefficient are presented in table 3.

Table 3

Years	2010	2012	2014
2010	1	0,972633	0,908046
2012	0,972633	1	0,914067
2014	0,908046	0,914067	1

The values of the Spearman's rank correlation coefficient in the years 2010, 2012 and 2014.

Source: Own elaboration based on Eurostat database

High values of the rank correlation coefficients indicate a stability of positions occupied by individual countries in the analyzed years, which also confirms the stability of the effects of proecological activities carried out by businesses in these countries.

Conclusions

The top positions in the ranking of the European Union countries in terms of the effects of proecological activities of enterprises in the context of zero waste logistic systems are taken by the countries with the highest environmental

awareness of the society. These countries have been implementing proecological solutions for years and environmental protection is a vital element of their functioning. The top ten positions in the ranking concerning the effects of proecological activities in every analyzed year are occupied by the countries of Western and Northern Europe (without the Baltic countries). This comes form the fact that enterprises in these countries are involved in proecological activity, especially with respect to the reduction of generated waste. Integration and coordination of these activities between cooperating businesses leads to the creation of a zero waste logistic system. One can conclude, therefore, that the effects of proecological activity of enterprises should be discussed in the context of zero waste logistic systems.

The analysis of the stability of effects of the proecological activity of enterprises in the context of zero waste logistic systems shows that in the individual years there is a convergence in the ranking of the examined countries in terms of the defined synthetic variable. Therefore, we can speak of a stability in the proecological behaviours of businesses which is a positive observation, especially if one considers the countries with the highest level of achieved effects. The increase in the development measure in the majority of countries in 2014 compared to the previous years means that enterprises are more willing to carry out proecological activity aimed at the creation of zero waste logistic systems.

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