

ANALYSIS OF THE IMPLEMENTATION OF CHANGES IN SUPPLY CHAINS TOWARDS A CIRCULAR ECONOMY

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Purpose: The purpose of the publication was to present the opportunities offered by the implementation of Cleaner Production projects in terms of improving the efficiency of supply chains, in accordance with the principles of transformation to the circular model, and to review indicators characterizing green supply chains, indicating the direction of further, in-depth research in a given area.

Methodology: Fourteen entities that implemented implementation projects under the Cleaner Production Academy were analyzed. On this basis, the degree of adaptation of selected enterprises to functioning in the circular model in such areas as transport, reverse logistics, cooperation, and eco-design was discussed. The economic account related to the above was balanced. Implementations, then the results of the projects were summarized in the form of economic, environmental, and social indicators.

Findings: Confrontation of the ways of implementing changes in the area of improving the efficiency of the functioning of the supply chains of the analyzed companies with the effects that have been achieved, showed the greatest commitment to projects reducing material losses and reducing the costs of internal logistics. The least involvement was found in the area of activities such as establishing cooperation with other companies or developing the service sphere.

Research implications: Further research should focus on an in-depth analysis of examples of good practice in the area of cooperation and development of services for companies taking action to improve the efficiency of supply chains. Enterprises have a chance to significantly reduce costs and improve the environmental effect through activities in this area, which should be confirmed by examples of implementations.

Practical implications: The analysis of the indicators suggested in the literature related to the transformation of supply chains towards closing the loops indicates the need to create standards that, on the one hand, will enable verification of the effects of implementations implemented as part of Cleaner Production projects, and on the other hand - will constitute know-how for companies. These activities, so far rarely undertaken by companies, are generally low-cost and probably enable achieving very good economic effects in the long term, which should be checked.

Social implications: The development of activities in the social area by companies in the field of development of the service base and cooperation will have an impact on other indicators (economic and environmental), which is indicated by numerous examples of effects in this area in the world literature.

Originality: The article takes a very important direction of further research in the area of know-how for taking actions aimed at closing supply chains. The authors look for the most universal indicators and pay attention to the need for their mutual complementation. The collected material is the starting point for further in-depth analyses.

Keywords: circular economy, supply chain, cleaner production.

Category of the paper: Viewpoint, Conceptual paper.

1. Introduction

The classic supply chain, according to the simplest definition, is a sequence of events in the movement of goods. Sequences of events occur between producers and service providers, who, in cooperation with each other, process and move goods and related information and financial resources, from the raw material to the end user (Kisperska-Moroń et al., 2017). The linear model of the supply chain, now common, ends at the target customer. The entire effort related to the movement, its main cost is the cost of transport, which in Poland is almost 78% for road transport, and the vast majority of this is dependent on crude oil, more than 33% from Russia, almost 12% from Norway and almost 9% from Saudi Arabia, which has its obvious economic consequences (Bachorz, 2017). Environmental consequences are the second very important argument in looking for solutions. The implementation of the assumptions contained in the "White Book" (Biała Księga, 2011) assumes a 60% reduction in greenhouse gas emissions by 2050 (the reference year 1990). The "Book" indicates the need to develop the use of new fuels and propulsion systems, the increase in the use of multimodal solutions, and the development of IT systems for transport fleet management. Changes in the transport also include the development of local and regional transport, while the most expensive international transport is losing its importance (which is possible because of moving production closer to the customer, also from distant regions of the world to Europe). The process of switching to the circular economy model means various solutions for supply chains that short it, loop it, and are not limited only to changes in transport.

Placing products with a longer service life on the market increases the share of the so-called "third participant" (Kisperska-Moroń et al., 2017), which is the service sector, and thus activates/unblocks channels operating in the opposite direction to the classical chain (Fig. 1).

The development of warranty/service facilities (which is also associated with the more frequent leasing of products by the customer than buying), makes enterprises narrow the scope of their operation to local areas, because this is the only way they can guarantee customers

quick service. It also requires easy and quick access to spare parts, which further narrows the scope of cooperation to local entities. Thus, it becomes necessary to cooperate within the framework of cooperation, clusters, and finally industrial symbioses, which, as well-defined both in the literature (Doniec, 2011). and proven in practice (e.g. the city of Kalundborg in Denmark) (Doniec, 2019), are the form of action recommended by the European Commission for market transforming towards a circular economy (Roadmap..., 2019).

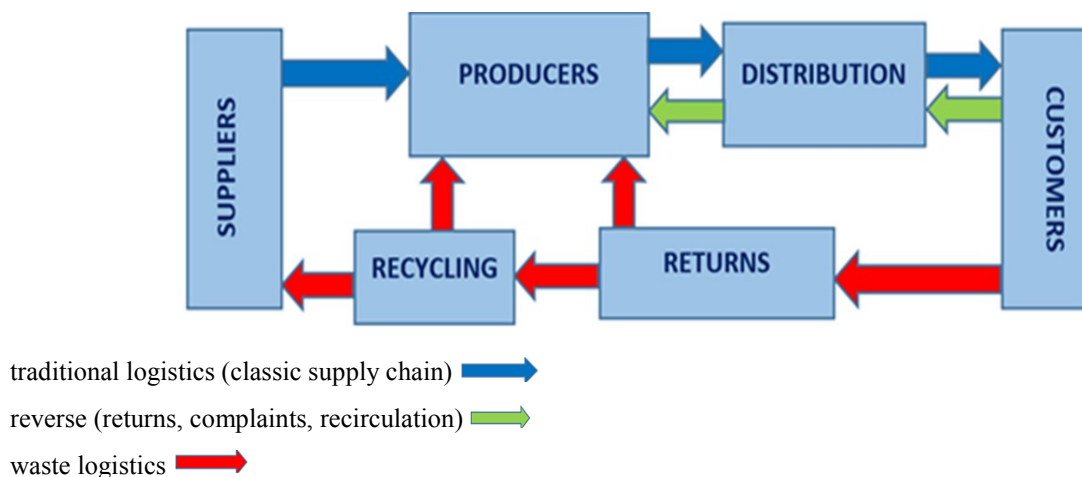


Figure 1. Logistic flows.

Source: Hordyńska, 2017.

Closed Loop Supply Chain allows you to manage your own materials, components and products in a closed cycle, and companies operating within the framework of symbiosis use all resources and energy at their disposal as efficiently as possible, exchanging utilities with each other in accordance with the principle "your waste it's my product".

There are many different forms of cooperation between the actors involved in the supply chain. Such cooperation also takes the form of a logistic partnership, with different levels of involvement of participants. The literature distinguishes (Kisperska-Moroń et al., 2017) four levels of cooperation as part of a partnership in the supply chain, ranging from the least durable form - having a short-term and competitive character, through the next two levels with increasing intensity of involvement, up to the fourth level, completely unique, characterizing a long-term partnership between participants. The fourth level, the so-called in-house, is based on the principles of partnership, transparency, and coordination of processes in achieving common goals. Of course, the most important for the development of all forms of cooperation in the supply chain are the possibilities of reducing the operating costs of enterprises, and these are primarily generated by: transport and storage. According to research (Kisperska-Moroń et al., 2017), the factors in the area of corporate social responsibility are the least motivating for cooperation, except for one factor, namely the increase in customer satisfaction, which is the second, after costs, strongest incentive for cooperation among all taken into account in the study. The least attractive for enterprises are the intentions to achieve pro-ecological goals and improve working conditions, therefore the first motivator, justifying the rightness of

undertaking it, must always be the economic factor, and the second - the well-being of the client (final recipient). And just as the economy in the supply chain will depend mainly on the costs of transport and warehousing, the well-being of the customer will depend on the degree of involvement in the supply chain of the service sector. The main two factors motivating to redefine the classical supply chain (economy and customer), at the same time have a decisive impact on reducing the impact on environment participating in the chain of entities. In this way, the efforts made spontaneously translate into a pro-environmental effect.

2. Cleaner Production Strategy

The concept of Cleaner Production was developed in the late 1980s on the basis of the idea of sustainable development. Even then, it was obvious that quick action was needed in view of the increasing amount of pollution in the environment and dwindling resources. It was becoming more and more aware that removing the effects of human activity requires the intensification of the so-called "At the source", and not only the interest in activities "at the end of the pipe" (sewage and exhaust gas treatment, safe disposal of waste). Acting "at the source" requires commitment by both producers and consumers, but above all - a change of mind. To broadly promote the new approach worldwide, in 1989, the United Nations Environment Program (UNEP) initiated the global Cleaner Production program, which today operates in more than 50 countries. The first national CP program was established in Poland and in 1998 it received the UN Global 500 award for its achievements. Since the beginning of CP's operation, 783 implementation projects have been carried out in Poland (www.cp.org.pl, 2021).

Both CP, EMAS, and ISO 14 000 contribute to the development of the megatrend (www.cp.org.pl, 2021), referred to as the Economy of Closed Circuit (circular economy), but the Cleaner Production strategy is the least formalized standard. Like all the others, it is based on the Deming cycle (PDCA - Plan-Do-Check-Act) and is based on continuous improvement. In practice, it means the realization and implementation of Cleaner Production Projects. The circular economy, like the CP, also promotes activities reducing pollution "at the source", recommending, for example, eco-design, i.e. designing production and service processes, supply chains, the functioning of product recipients, etc. the cradle-to-cradle principle (the product then becomes the raw material). However, he does not give up on improving the already existing solutions in every area of the company's operation and transforming them into more and more environmentally friendly solutions. The closed loop of GOZ is, like in the case of CP, continuous improvement, carried out on many levels.

Transformation towards a circular economy is the only way to counteract climate change that the 21st century has to face. Changes in supply chains are particularly important due to the need to reduce greenhouse gas emissions, and according to the calculations

(<https://przemyslprzyszlosci.gov.pl>, 2021), transport is responsible for 25% of greenhouse gas emissions in Europe. Solutions such as electric and hydrogen drive for cars, increasing the share of renewable energy, or solutions enabling an increase in the share of rail and sea transport in supply chains will contribute to a significant reduction in emissions by 2050. The involvement of individual countries in legislative processes and supporting enterprises and society in change processes (Roadmap..., 2019). Cleaner Production is one of the ways to initiate the transformation process, as mentioned - the least formalized one, enabling the start of changes using the so-called "Little steps" or "low-hanging fruit". It is a method that activates all employees of the company. The action begins with an audit, the aim of which is to search for such opportunities for changes that do not require large financial outlays (or do not require them at all), and give spectacular economic effects. The economic effects and, at the same time, the reduction of environmental pressure make employees engage in new projects. There is one more effect that strongly motivates action - the social effect, which in the case of supply chains plays a great role in acquiring suppliers on the one hand, and on the other - has a strong marketing impact on the customer. Therefore, it is a serious advantage compared to the competition.

3. Characteristics of selected enterprises

Adapting to the new reality requires changes in action, but most of all in thinking about one's own business and encourages to take a number of initiatives within the closed loop of the supply chain (Karwacka, Łuba, 2016). The implementation of Cleaner Production Projects enables the implementation of the assumptions of the circular transformation at a pace adapted to the specificity of the industry, financial and human resources capabilities of the company - it enables comprehensive transformation in the following areas: ecological, environmental, and social, in accordance with the assumptions of sustainable development (<https://kampania17celow.pl>, 2021).

The analysis covered 14 entities implementing an implementation project (Cleaner Production Project) in 2010-2018, improving the functioning of the supply chain: 7 production companies, 3 production and service companies, 1 educational institution, 1 NGO, 1 city office, 1 service company. All projects were implemented showing economic effects in the first year after implementation or showing a payback period (from approx. 1.5 to 12 years). The implemented changes mainly concerned the improvement of waste management. They concerned both high-cost and non-costly investments related, for example, to organizational changes in the enterprise.

Table 1.

List of selected companies implementing CP Projects in the period 2010-2018 in the area of changes in supply chains towards circular economy with an indication of the economic benefits of the implemented project

No.	Enterprise	Changes in supply chains in selected companies in areas such as:				
		Transport	Reverse Logistics	Cooperation	Eco-designing	SAVED AMOUNT [PLN/year]
1	Production			X	X	return after 2 years
2	Production/ services	X				17 346
3	Production/ services		X			return after 3-4 years
4	Town hall		X			516 510
5	NGO		X	X		16 038
6	School		X			2 826
7	Services		X			return after 34 mth
8	Production		X			3 351
9	Production		X			373
10	Production/ services		X			return after 12 years
11	Production		X		X	24 960
12	Production		X	X		29 518
13	Production		X		X	166 000
14	Production		X	X		28 502
The amount of investment: Gain [in 1 year] SUM:		1	12	4	3	607 287

Source: own study.

In the vast majority of cases, changes were made to the internal and external organization of the supply chain and waste was redirected to own production processes or transferred segregated to specialized companies. Significantly less investments, but also in the area of eco-design, - three companies redesigned their production processes, thus improving the flow in supply chains. Cooperation with another entity, enabling changes in the supply chain, was undertaken by two companies and only one made changes towards a more effective vehicle (Table 1).

Table 2.

List of economic, environmental and social indicators in selected companies implementing CP Projects in 2010-2018 in the field of innovation in supply chains towards circular economy

No.	Enterprise	Economic indicators		Environmental indicators		Social indicators		SUM
		Drop in internal logistics costs	Decrease in external logistics costs	Reduction of material losses	Reduction of CO ₂ emissions	Cooperation	Services	
1	Production	+	-	+	+	+	-	4
2	Production/ services	-	-	+	+	-	-	2
3	Production/ services	+	+	+	+	-	-	4
4	Town hall	+	+	+	-	-	-	3
5	NGO	+	+	+	-	+	-	4
6	School	+	+	+	-	-	-	3
7	Services	+	-	+	-	-	-	2
8	Production	+	-	+	-	-	-	2
9	Production	+	+	+	-	-	-	3
10	Production/ services	+	+	+	-	-	-	3
11	Production	+	+	+	-	-	-	3
12	Production	+	+	+	+	+	-	5
13	Production	+	+	+	+	-	-	4
14	Production	+	+	+	+	+	+	6
SUM:		23		20		5		48

Source: own study based on (Kulczycka, 2020).

The highest economic indicators in the field of circular economy (Table 2) (23 in total - the highest result) result in the overwhelming majority of cases from the reduction of environmental charges incurred by enterprises so far. The next (20 in total) environmental indicators owe their high result to the reduction of raw materials and energy consumption. The lowest result was achieved by social indicators due to the very low level of cooperation and development of services by the analyzed enterprises and entities. Examples of social benefits by generally lofty-sounding entities: education, increasing ecological awareness, motivating to act, stimulating ecological sensitivity, raising awareness of ecological problems, learning ecological responsibility, etc. - usually without specific examples, and therefore without the possibility of their verification.

Table 3.*Examples of indicators related to the transformation of supply chains towards closing loops*

No.	Action	Effect
1	Changing materials or packaging	Transport weight reduction
2	Product redesign, material change, modular construction	Extending the product life cycle
3	Reduction of energy and material consumption in the production and use phases	Lowering energy bills, purchasing raw materials
4	Limiting the use of hazardous materials, harmful substances in products and production processes	Reducing the risk of occupational diseases and absenteeism at work, the risk of environmental contamination
5	Designing with material logistics in mind, selection of components	Facilitating production and assembly processes
6	Development of the service base (maintenance/repair)	Additional income from business expansion, maintaining control of the reverse chain
7	Cooperation/collaboration/symbiosis /creating clusters/cooperatives	Lowering the cost of operating in the market for common economic benefits
8	Creation of conditions conducive to better consumer choices (lease, rental, sharing), which are an alternative to owning products	Full control over return streams, the possibility of stable development of the service area and recovery (certain quality and quantity of raw material)

Source: own study based on (Tundys, 2015; Kronenberg, Bergier, 2010).

The results of the analysis show that in order to systematize solutions related to the creation of closed loops of the supply chain, in accordance with the transformation towards a circular economy, criteria should be proposed that will enable enterprises to verify activities in terms of a new economic approach, especially in the field of expanding cooperation with external entities and with development of the service sphere (Tundys, 2015). Including e.g., a website in the chain or cooperation with local enterprises as part of sharing or joint educational and marketing activities, even to a small extent, will be profitable both financially and in terms of promotion for entities participating in the project.

In the literature, you can find many searches for the best indicators for verifying actions towards circular economy, also, and maybe in particular, for actions taken towards the transformation of supply chains (Kulczycka, 2020; Tundys, 2015; Dendera-Gruszka et al., 2017; Kronenberg, Bergier, 2010; Mohamoumgonbadi et al., 2021). The best means the most comparable, reliable, but also easy to use. Tundys (Tundys, 2015) proposes to assess the adaptation of supply chains on the basis of descriptive indicators developed on the basis of the EC Communication (COM 2014) [17], Kronenberg, Bergier (Kronenberg, Bergier, 2010) in turn - based on the guidelines for eco-design (Table 3).

The effects of activities undertaken by enterprises towards circular transformation must take into account the entire value chain. Only then will they allow the circuit to be fully closed. The most important stage of transformation is product design, which requires close cooperation of everyone involved at every stage of the supply chain (Metta, Badurdeen, 2012). A systemic

approach to creating new business models is a necessity. It is also necessary to use the results of the product life cycle analysis in their creation as the most reliable tool that comprehensively covers the entire supply chain (Kulczycka, 2020). LCA analysis (Kulczycka, Góralczyk, 2007), not very common so far due to the cost and time-consuming nature of the analysis, will become a commonly used method with time. It is already known today that it is the only method that allows the company to be assessed from the perspective of the entire supply chain. Here, the key is not only that the company implements the assumptions of circular economy, but also that those cooperating with a given enterprise are also assessed in terms of the implementation of circular economy assumptions.

Three indicators can be used to assess the efficiency of the supply chain in a company: the level of total logistics costs, the level of inventory costs and the effectiveness of financing the logistics system (Dendera-Gruszka, 2017).

- The level of total logistics costs can be determined by the formula:

$$W_{KL} = K_L \times 100 / P \text{ [PLN]} \quad (1)$$

where:

K_L - logistics cost,

P - company's turnover.

- The level of inventory costs is:

$$WKZ = K_Z \times 100 / M_Z \text{ [PLN]} \quad (2)$$

where:

K_Z - inventory cost,

M_Z - Inventory Value.

- Effectiveness of financing the logistics system:

$$EPSL = E_{KM} + E_{KT} + E_i + E_P \text{ [PLN]} \quad (3)$$

where:

E_{KM} - effects obtained due to the reduction of the costs of the movement of goods,

E_{KT} - effects achieved as a result of reducing inventory costs,

E_i - results obtained from reducing the costs of IT processes,

E_P - other effects.

Effectiveness assessment also begins with examining the flow of information and relationships within the supply chain. Then, if necessary, the information flow should be improved, first of all eliminating all disturbances. If the flow of information between the supply chain partners is at least at an acceptable level, the analysis and evaluation of other components of the supply chain can be undertaken (Klein, Rai, 2009).

In order to fully measure the effectiveness of the supply chain, it is also necessary to calculate the efficiency of transport, storage, material flow processes, and the spread of innovation. Calculations should be made for the processes before and after the implementation of the changes to compare the performance indicators. Considering the need to conduct an analysis towards implementations enabling the transformation of the supply chain towards

circular economy, all indicators should be analyzed in terms of the intensity of their impact on the adaptation of the company to the circular model.

In their publication (Kulczycka, 2020), the authors look for indicators that will be the most universal and pay attention to the need to complement each other. The search for a universal tool is still ongoing, unfortunately, no ideal solution has been proposed yet. More and more companies in their reports on the climate footprint pay a lot of attention to the analysis of the supply chain, but it is still not a common activity (Qiang Du, Jiajie Zhou, 2022).

4. Conclusions

The analyzed enterprises, by implementing the Cleaner Production strategy, made a step towards the implementation of the circular economy assumptions. Some of them carry out CP Projects on a continuous basis, perfecting their approach and achieving very specific benefits. Some of them are only just starting activities aimed at organizing the environmental policy.

The results of the analysis confirm that the indicators most frequently reported by enterprises in the field of circular economy in Poland are those in the area of waste, concerning CO₂ and water emissions (Kulczycka, 2020). The publications contain many examples of companies that are created from scratch and function perfectly in the circular economy model based on new business models. Unfortunately for companies that have been operating on the market for many years, it is very difficult to change the business profile or even just expand it without comprehensive support for such a transformation. And this requires not only financial support, but above all interference in the organizational culture, and thus training and motivation to take non-routine activities.

Analysis conclusions:

1. The implementation of the Cleaner Production Project enables comprehensive actions to be taken by arranging them, hierarchizing them, and providing comprehensive advice and support from both the expert side and examples of implementations that can be used on the basis of benchmarking.
2. The review of activities undertaken by the 14th cleaner production companies revealed as many as 12 activities in the area of reverse logistics and only 4 aimed at cooperation with other entities on the market or at the development of the service sphere (only 1), which would shorten the supply chain.
3. Observing the market needs it can be assumed that it would be necessary to provide enterprises with transformation know-how in this area.

4. Diagnosed by the authors, the least reported changes in the scope of delivery, regarding cooperation and development of the service sphere and eco-design, are also emphasized in the priority literature, but also the least reported in relation to the improvement of the economic effect of the company.

The conclusions of the analysis of the world literature report formulated in this way (Mohamoumgonbadi et al., 2021; Metta, Badurdeen 2012; Klein, Rai, 2009; Qiang Du, Jiajie Zhou, 2022), the development of a closed-loop study is widely analyzed. Numerous examples included that the benefits of using enterprise action are seen here that are involved in the supply chain, marginally analyzing the application and society aspects, which has also been confirmed in the inclusion based on some research. Beware of researchers for this analysis, which may not be due to the failure of the company to perform actions, but due to the fact that, firstly, the priority classical treatment, economic factors, are included in the exact inputs and take into account the rates of return, and the lack of norms that would arise in based on good practices as benchmarks. Companies probably do not see the role of social aspects in the regionalization of supply chains, which deserves more attention as a trend for the future, especially after the experience of the COVID pandemic and the current problems on the global market due to Russia's aggression against Ukraine. It is also necessary to support the companies in the supply chains transformation towards developing and implementing tools that improve the connection and flow of information, not only in the field of equipment but also by personnel.

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