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Digital supply chains and the development of the circular economy (part 2)

Cyfrowe łańcuchy dostaw a rozwój gospodarki o obiegu zamkniętym (cz. 2)

Abstract

Nowadays one of the biggest challenge for modern business entities is the introduction of solutions and assessments of environmental optimization in the supply chain (reducing the resource-intensiveness of the economy) and the search for waste-free solutions (facing the issues of losing the status of waste, by-products or accompanying products). These challenges are built in relation to the goals and scope of the Circular Economy (CE), which is conducive to the implementation of solutions aimed at sustainable development. The aim of this paper is to identify the possibilities of achieving environmental optimization due to the use of digital technologies and the concept of digital supply chains in the conditions shaped by the CE. The adopted research question is: "To what extent can digital supply chains affect the development of CE?"

Keywords:
digital supply chain, digital circular supply chain, circular economy

Streszczenie

Obecnie jednym z największych wyzwań dla nowoczesnych podmiotów gospodarczych jest wprowadzanie rozwiązań i ocen optymalizacji środowiskowej w łańcuchu dostaw (zmniejszanie zasobochłonności gospodarki) oraz poszukiwanie rozwiązań bezodpadowych. Wyzwania te budowane są w odniesieniu do celów i zakresu gospodarki o obiegu zamkniętym, co sprzyja wdrażaniu rozwiązań ukierunkowanych na zrównoważony rozwój. Celem artykułu jest identyfikacja możliwości osiągnięcia optymalizacji środowiskowej dzięki wykorzystaniu technologii cyfrowych oraz koncepcji cyfrowych łańcuchów dostaw w warunkach kształtowanych przez gospodarkę o obiegu zamkniętym. Przyjęte pytanie badawcze brzmi: „W jakim stopniu cyfrowe łańcuchy dostaw mogą wpłynąć na rozwój gospodarki o obiegu zamkniętym?”.

Stowa kluczowe:
cyfrowy łańcuch dostaw, cyfrowy łańcuch dostaw o obiegu zamkniętym, gospodarka o obiegu zamkniętym

JEL: M21, Q55

Introduction

The first part of the work (Nowicka, 2023) focused on defining the meaning of the concept of a digital supply chain and defining its properties that are a potential starting point for responding to the needs of the Circular Economy (CE). An approach indicating the possibility of implementing the closed-loop concept was distinguished, with particular emphasis on the role of Artificial Intelligence (AI) in the built platform understood as a digital supply chain. The use of an ecosystem of diverse digital technologies (including AI) enables the introduction of dynamics in the created business models. These technologies, on the other hand, can support building dynamic capabilities of a strategic enterprise (Nowicka, 2019) and be used to achieve goals related to its sustainable development.

Bearing in mind the previously indicated stimulants for the development of the digital economy and the dissemination of the use of digital technologies in management, it was assumed that the purpose of this work is to identify the possibilities of achieving environmental optimization due to the use of digital technologies and the concept of digital supply chains in the conditions

shaped by the CE. The adopted research question is: To what extent can digital supply chains affect the development of CE?

Thus, in the second key area of the work, the focus was on the conditions shaping CE business models. The essence of achieving the adopted goal of this work is the possibility of confronting the pro-ecological potential of digital supply chains with the assumptions of the CE. As a result, various models of digital circular supply chains (Digital Circular Supply Chain) are created, affecting the natural environment in a diverse way, and therefore constituting an interesting solution for promoting the development of CE in the cognitive and application perspective.

The work assumes that the micro approach stimulates the development of the macro concept by expanding and placing the main emphasis on the role of digital technologies (and platforms built on its foundations) as a key stimulant of the CE. The work is conceptual. In the research procedure, the research problem was first formulated, the research question was asked and the research goal was adopted. At a later stage, a literature review was carried out (the focus was on the latest scientific articles, but also industry reports and other sources supporting finding the answer to the research question), they were analysed in terms of the assumed research objective and conclusions were made. In the research procedure, in addition to the implementation of the adopted goal, some research gaps and areas worth further scientific exploration were also identified. Thus, the work can be a starting point for further in-depth research on the role of digital technologies in improving the sustainable development of the economy. Detailed conclusions and recommendations are included in the summary of the work.

Conditions for shaping business models in circular economy

"The principles, assumptions and models of the CE today shape the goals and directions of activities of the European Commission, countries, regions and cities. They are an impulse and encouragement to introduce this type of strategy in manufacturing and service companies" (Kulczycka, 2020, p. 40). As noted in the introduction to the work, environmental optimization in the supply chain, reducing the resource-intensiveness of the economy and the search for solutions that do not create waste, is a special challenge for business entities today. When looking for answers to these calls, it is worth identifying the range of factors shaping the way of functioning according to the CE principles.

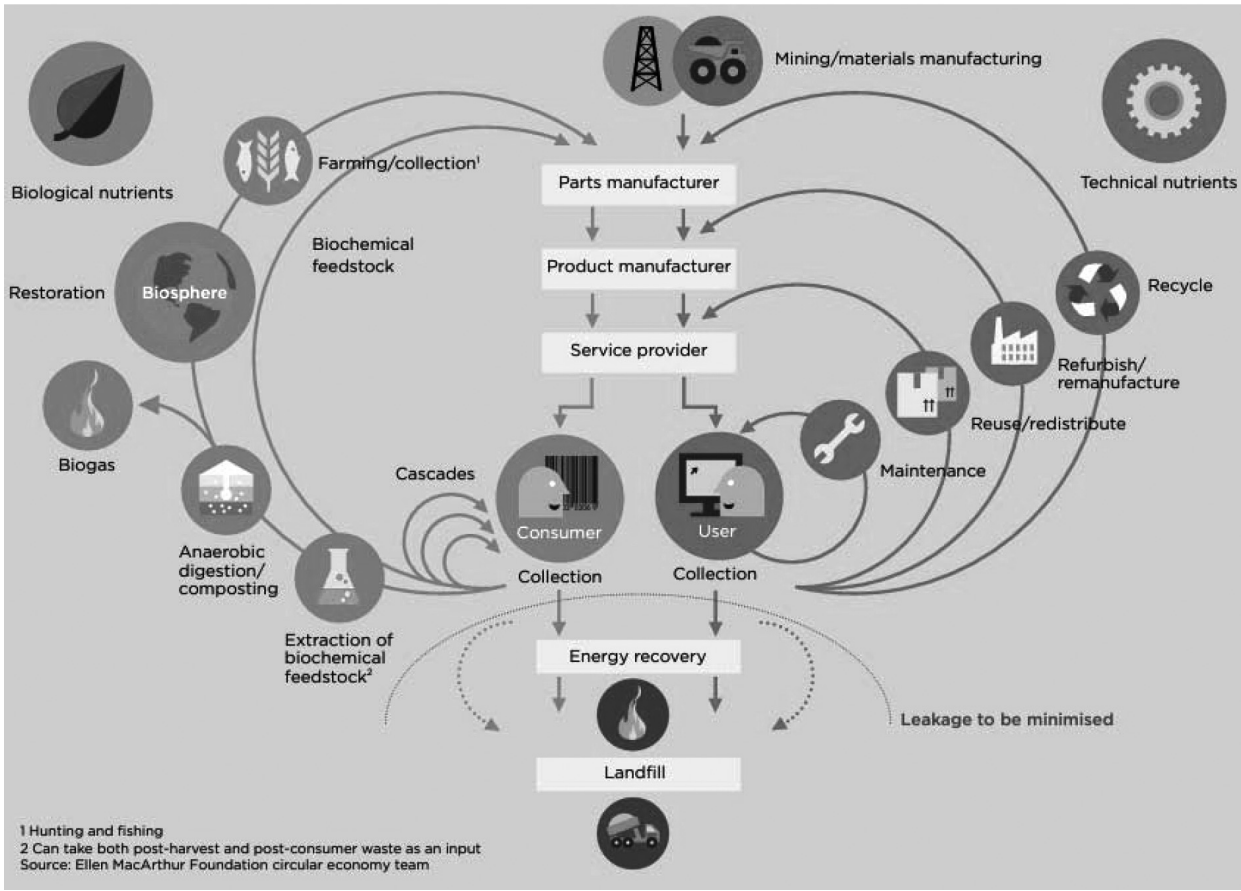
CE determines the building or reconfiguration of business models aimed at extending the product life cycle by enabling the transition from the declining phase to the (next) development phase. In this way, cycles are closed in which used products are new resources subject to further processing (marketing and technological) in order to minimize the level of waste generation subject to disposal. Naturally, the key role here is played by raw materials and components used to produce a given product, the characteristics of which enable, to a greater or lesser extent, the activation of the cycle closure loop at various stages of the distribution of goods or force the construction of a new flow model of "new" products. The point of reference is therefore the product design stage, within which the product life cycle or product life cycles following the original one are defined. As in the case of IKEA, where designing the value proposition is determined by limiting unit logistics costs (products are to fit into flat boxes so that as many of them as possible fit in the means of transport and on the shelves in the store), so in this case the value proposition – in addition to meeting customer expectations – it is to meet a number of other assumptions. These assumptions result from the previously indicated maximally extended product life cycle.

In the CE, cycles are closed at various levels and concern both the sphere related to the characteristics of the product itself and the way of managing the flows of these products. In Figure 1, these are indicated as biological cycles (involving streams of renewable materials) and technical cycles (based on the management of stocks of non-renewable materials, where use replaces consumption by recovering and restoring most of the technical materials) (Fundacja Ellen MacArthur, 2015, p. 7).

Both cycles indicated in Figure 1 are in a mutual relationship, within which the characteristics of the product determine the choice (or organization) of the method and stage of closing the flow cycle. In CE, value is created through (Fundacja Ellen MacArthur, 2015, p. 8):

- the strength of the internal loop, assuming that the tighter the loop, the better the strategy, as the value obtained in this way is higher than in the case of recycling materials;
- the power of extended circulation aimed at increasing the number of consecutive cycles and/or the duration of each cycle for the product (e.g. reusing the product several times or extending its life cycle);
- strength of cascading use related to diversification of reuse along the value chain;
- the power of clean input materials to extend product life and increase material productivity.

Figure 1
Circular economy – biological and technical flows



Source: Fundacja Ellen MacArthur, 2015, s. 7.

The implementation of the principles, assumptions and building CE business models should be consistent with other important strategic documents at the level of the UN and the European Union (EU), especially in the context of the implementation of the commitments made. This applies above all (Kulczycka (Ed.), 2020, pp. 11–12):

- Agenda 2030 (Agenda 2030), i.e. monitoring progress in the implementation of sustainable development goals. The Agenda is voluntary and is not anchored in financial instruments, but it sets a global model for sustainable development.
- The European Green Deal, which is a signpost of the EU's climate and energy policy, indicating the need to mobilize the industry, e.g. for the transformation of the economy towards a CE. The main assumptions of the European Green Deal are presented in Figure 2.

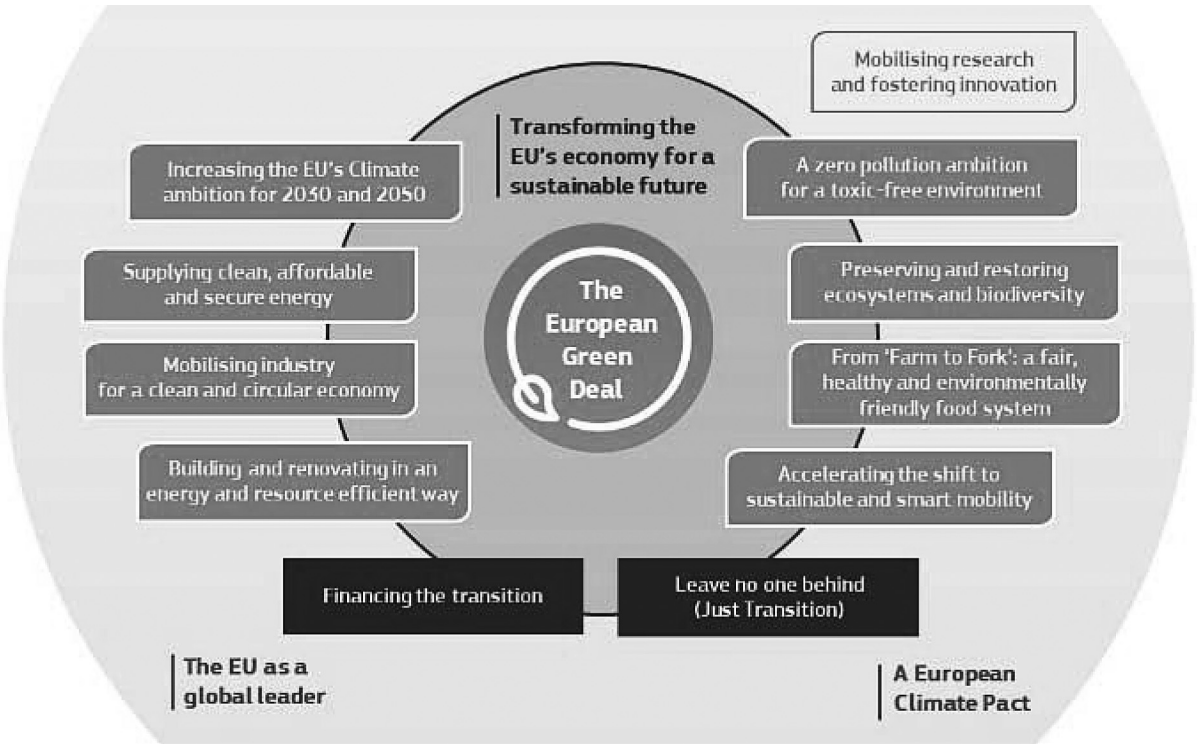
European Green Deal is an important source of knowledge supporting the shaping of the rules of conduct of companies on the market aimed at limiting the negative external effects of running a business. Membership in the EU means that the European Green Deal will apply to all Polish entrepreneurs. For this reason, when planning their further operation, enterprises should take into account such aspects as:

- designing environmentally friendly products (Ecodesign), taking into account the reduction of plastic and the use of recycled materials,
- waste prevention (including packaging waste),
- extended producer responsibility,
- emphasis on decarbonisation and certificates demonstrating CO_2 removal,
- reporting non-financial data,
- green public procurement.

In addition, the principles of CE today shape the structure of the main strategic documents of the state, which can be included (Kulczycka (Ed.), 2020, pp. 11–12):

- Strategy for Responsible Development adopted in February 2017, the main objective of which is to create conditions for increasing the income of Polish residents, while increasing cohesion in the social, economic, environmental and territorial dimensions.

Figure 2
European Green Deal



Source: European Commission, 2019.

- A productivity strategy, the main goal of which is a progressive increase in productivity in the conditions of a climate-neutral, circular and data-driven economy.
- National Environmental Policy 2030 – development strategy in the field of environment and water management – focused on development opportunities in non-urbanized areas.
- National Plan for Energy and Climate for 2021–2030, which sets the following climate and energy goals for 2030: 21–23% share of renewable energy sources (RES) in total gross energy consumption, increase in energy efficiency by 23%, reduction to 56–60% of the share of coal in electricity production.

The regulations themselves can be a strong incentive to initiate pro-ecological activities in the company and its supply chains and to verify the implemented strategy. For this purpose, it is worth considering the previously indicated potential of digital technologies that meet not only the improvement of competitiveness in the economic area, but also support pro-ecological activities (on which the factors shaping CE focus) and pro-social activities.

Impact of digital supply chains on the development of circular economy – opportunities and challenges

CE is an increasingly clear background and reference point for creating new business models, conditioning the rules of their functioning. Sustainable business models built in it, i.e. pursuing economic, pro-ecological and pro-social goals at the same time, force a broadening of the perspective of understanding business management and a change of approach in several dimensions. These include the need to change perspectives in the following approaches (Breuer et al., 2018, pp. 256–286):

- from consumers to stakeholders,
- from profit to diversified values,
- from a single solution (business model) to a network perspective,
- from focus on organization to systemic thinking.

While the awareness of this "enlarged perspective" is not a new level of competition, the ability to maximize the benefits of opportunities emerging in the environment against available and used resources can still be a challenge.

Firstly, however, it is worth noting that today it is not enterprises, but supply chains that compete. This assumption includes several characteristics that determine the concept of the supply chain understood as an "extended enterprise". These include, for example, managing relations with various stakeholders, a systemic approach, competing in demand networks. Thus, thinking in terms of supply chain management alone gives a certain advantage on the modern market. This thinking should be followed by actions allowing for the achievement of priority annuities (also in the context of offering differentiated value). Among some of them, it is worth highlighting the use of dynamic capabilities (with the support of digital technologies) that enable the continuous flexibility of the business model (supply chain) to be maintained, allowing not only to maintain business continuity, but also to be proactive towards the expectations and potential needs of consumers and other stakeholders. Another activity worth paying attention to is the diversification of business models (also supporting the possibility of differentiating the value proposition), or rather the correct diagnosis of flows carried out within the network in which the enterprise operates and their development giving the opportunity to achieve the greatest economic benefits.

It is worth noting that the issues of organizing flows and creating value within the CE de facto affect the company's strategy (Nowicka (Ed.), 2022a, 2022b). It determines the selection of components used for the production of a given good, i.e. the structure of suppliers who will co-create the value proposition that determines the possibility of their further processing, i.e. the structure of the supply chain on the distribution side. These, only partially indicated, simple dependencies emphasize the key issue of the need to implement a systemic approach in managing the company and its supply chains. Thus, the adoption of a strategy based on the concept of a closed circuit is connected with the need to revise all elements of the business model, as well as the need to diagnose the availability of new resources and the conditions of functioning in the new economic environment. We are talking here not only about meeting the conditions of sustainable development, but also about designing supply chain business models subordinated to the need to close cycles (Sustainability by Design). This is a differentiator from other strategies, e.g. focused on innovation or low costs, in which the essential elements of the business model, sources of supply or distribution methods in most cases do not have to undergo significant changes, or even no changes at all. Moreover, the concept is proactive rather than reactive. It is connected with the need to take into account the characteristics of the product (mainly natural – biological) in the design of its flows enabling the closing of cycles at various levels of the supply chain.

At the same time, the possibility of maximizing the extension of the product life cycle results from its adequate design in the context of the selection of components characterized by the possibility of their further use within the same value proposition or its new form – also in the context of increasing the scope of functionality – of the same product (value creation). However, this is not a sufficient condition. The second key aspect giving competitive advantages within the strategy based on the concept of circularity is the ability to design models of flows of this value proposition in the paths that close the loops at various stages of the entire supply chain (value delivery). It should be emphasized that both indicated areas are interdependent and only in the case of a systemic approach to designing the entire business model, one can talk about the possibility of maximizing the benefits (value capturing) resulting from the adoption of the closed-loop strategy.

A systemic approach and the adoption of a closed-loop strategy can be implemented with the support of technological solutions in the form of a platform used to shape competitive supply chain business models. Because the platform, as indicated earlier – defined by the European Commission as an "enterprise" (Komisja Europejska, 2015) – thanks to the use of modern technologies, mainly cloud tools (Nowicka, 2016, pp. 69–88), provides a whole set of ready-made solutions offering an opportunity to quickly develop multi-channel and complementarity of distribution channels, their circularity and cooperation with the consumer and other stakeholders of enterprises cooperating within the network.

Another, more technologically advanced solution is to build a supply chain business model fully based on digital technologies, which is the digital supply chain, which, by the way, can also be understood as a platform. Each of these supply chain business models is the result of a combination of the use of the platform (and thus digital technologies underlying the building of the company's dynamic capacity structure) and can be dedicated to building sustainable solutions based on the assumptions of the CE while being able to develop and multiply its positive effects in macro terms.

In addition, it is worth noting that the closed loop of information and product flow in the supply chain can be one of the components in building a digital supply chain. In such a solution, AI can become a plane and a stimulant of these flows, playing a planning and executive role, co-deciding on the

rhythm and scope of individual flows in the cycle of closing their loops. The described model was based on the results of a survey conducted among over 1,600 supply chain managers in 33 countries on a global scale in the period from October 2019 to January 2020 by PwC, and its components include (Geissbauer et al., 2020, p. 12):

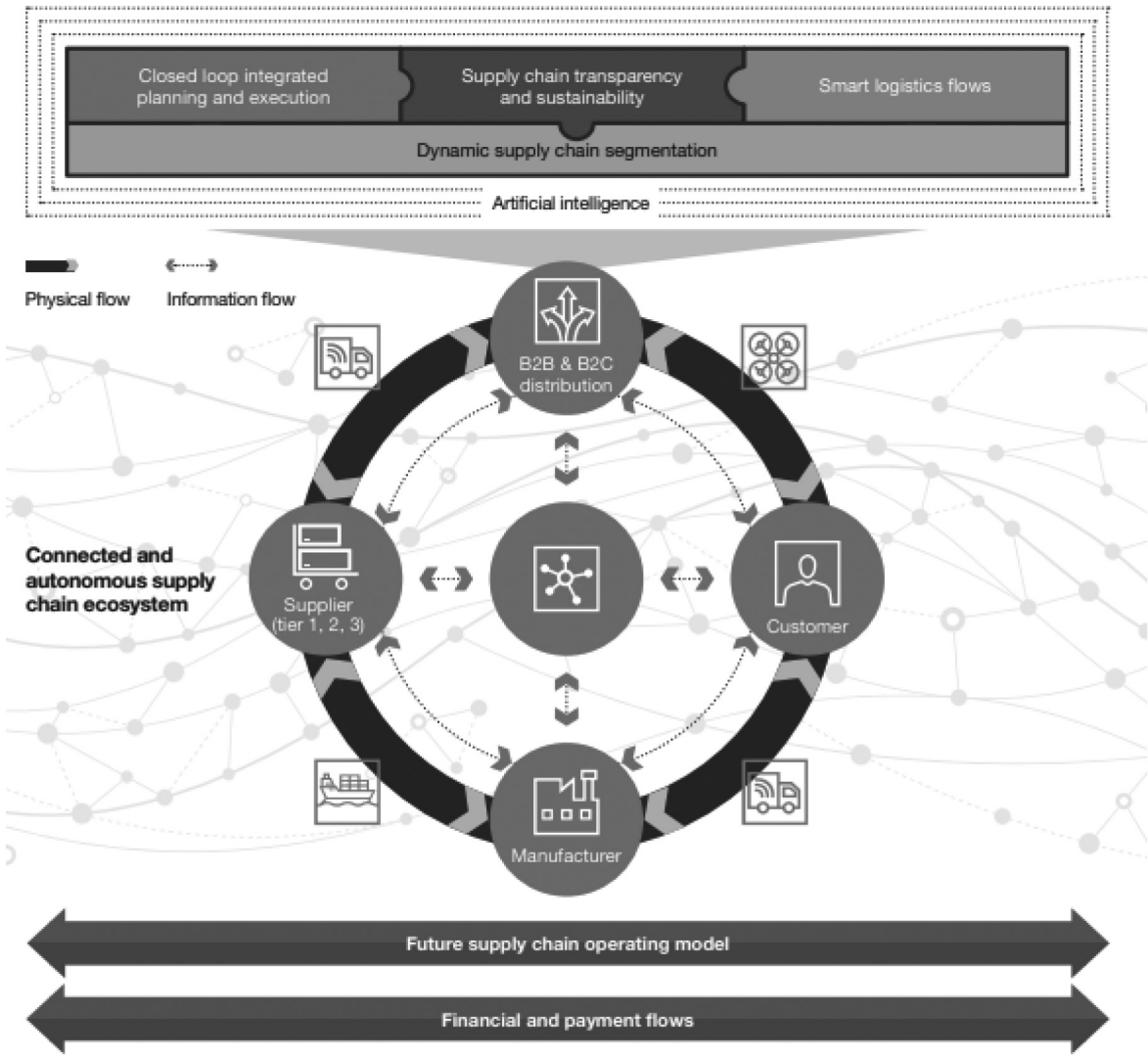
1. Closed-loop integrated planning and execution: end-to-end planning from customers to sub-suppliers, covering short and long-term time horizons and integrating financial and volume plans, continuous balancing of supply and demand, direct connection to executive activities, collaborative workflows and automated decision making thanks to advanced analytics.
2. Transparency and sustainable development of the supply chain: multi-level data flow and their constant connection between links in the entire supply chain, ensuring full insight into the implemented processes, flows of goods, access to customer and financial information. A fully transparent and sustainable supply chain enables the reuse of materials, the extension of the life cycle of finished products and services, and the integration of suppliers and other stakeholders.
3. Intelligent logistics flows: multimodal inbound and outbound transportation, automated warehouses, efficient Transport Management Systems (TMS) and Warehouse Management Systems (WMS), optimized external distribution costs, multichannel and omnichannel order management.
4. Dynamic segmentation of the supply chain to differentiate the value proposition and its targeting within the network to different customers and other stakeholder groups. This is possible thanks to the flexibility and adaptability based on the properties of digital technologies. The supply chains built are easy to reconfigure also as part of the flows that close the cycles, depending on the current market conditions and the specificity of the product (i.e. the biological and technical cycle).
5. AI-based supply chain management. The use of fully connected data networks by AI in the supply chain to improve the quality of demand forecasting (also thanks to its detection). Identification of behaviours and various events during the execution of flows using machine learning in the supply chain allows you to build autonomous business models that optimize decisions aimed at achieving strategic goals.

The supply chain model based on an AI-supported platform along with its key components is shown in Figure 3.

The issues of progressive technological development and the entire digital economy strongly shaping modern business models are focused mainly on economic benefits. Competing with the use of technology shortens the time of process execution, eliminates unnecessary inter-mediaries, or gives access to new resources in real time on a global scale. Only those properties that directly affect transaction costs cannot be omitted by modern business managers. At the same time, the use (and building) of platforms, which are an integral element of the concept of digital supply chains, can be an attractive solution for companies implementing sustainable development strategies through the demonstrated properties. This situation also applies to business management in CE. Building a business model of the CE supply chain with the use of digital technologies makes it possible to dynamically connect various stakeholder groups and focus activities on diversifying the value proposition offered while respecting the natural environment. This is primarily a consequence of access to information enabling the management of goods flows in partner networks, as well as the ability to make strategic choices regarding the sources of supply, both in terms of the core of the supplied goods and all supplies indirectly related to it. In addition, the use of technology in supply chain management multiplies product reuse opportunities (e.g. by offering new functionality or converting to digital form) and extends the product life cycle. The platform supporting the implementation of the supply chain management objective, which is the basis for building a digital supply chain, also has a systemic approach inscribed in its architecture, enabling the simultaneous management of de facto several supply chain models (and closing several cycles at different levels), giving a chance to reconfigure them in real time. It is also a strong incentive to build a risk management strategy in the management of a circular digital supply chain.

An undoubted challenge, however, is the need to assume that the construction of such a supply chain model (as well as any other model that meets the requirements of CE) should be carried out in the rigor of limiting the negative external effects of running a business, i.e. levelling the formation of external costs. The relatively difficult measurement of the impact of running a business on people and institutions that are not stakeholders of the company (including the supply chains managed by them) seems to be an important tool defining sustainable development, and therefore the legitimacy of implementing circular business models and the entire CE. Another important aspect, also not being the main point of reference for this work, is the competence of supply chain managers in the selection of adequate technologies, or rather their ecosystem, enabling the company to maximize the benefits of their properties in relation to business needs.

Figure 3
Digital supply chain based on AI



Source: Geissbauer et al., 2020, p. 13.

Summary

The main stimulant of the development of the digital economy – digital technologies – is an interesting tool enabling the development of business models supporting the implementation of the sustainable development strategy. One of the important solutions in this area is the Internet platform model, which is increasingly used in various industries on a global scale. This dissemination is dictated mainly by economic considerations influenced by the characteristics of digital technologies. However, digital supply chains based on the platform and additionally using AI technologies in their ecosystems are also able to support the implementation of pro-environmental goals – the main point of reference for the development of CE. Circular digital supply chains implement a systemic approach, taking into account the perspective of many stakeholder groups, enabling differentiation of values in the network in which they operate. The possibility of closing the cycles of the flow of goods simultaneously at various levels intensifies the key forces that determine the essence of the CE concept. A necessary condition here is, of course, the adoption of an adequate company strategy that assigns all activities – including the way of implementing flows in the supply chain and its other constructs – to the implementation of sustainable development goals in accordance with the principles of CE.

The assumption of the work was its conceptual nature, however, it is possible to indicate several aspects with application features, as well as planes

that may be a starting point for further research. First of all, by running a business using digital technologies (taking care of the interoperability of the implemented solutions), entrepreneurs gain basically unlimited potential to create or reconfigure business models that implement various strategies and strategic goals. In the situation of supply chain management with the use of such resources, the dynamics of adapting to changes in the closer and further environment may concern international business models or global supply chains. As a result, the risk is limited (e.g. related to lost opportunities or freezing capital in resources, keeping "ready" for potential events, e.g. a sharp increase in demand). This fact alone is an important premise for the implementation of technology in supply chain processes. The ability to reconfigure flows with the use of technology also gives an opportunity to change the model faster in the case of transition to the implementation of the CE strategy.

Undoubtedly, the need to develop research on the external costs of doing business using the closed-loop digital supply chain model remains an important issue. At the same time, it would be important to determine these costs not only in relation to the flows carried out in this model, but also the external costs created by the supply chains of digital technologies, which are a strategic resource of circular digital supply chains.

References/Bibliografia

Amazon Web Services. (b.r.). Machine Learning on AWS. *Putting machine learning in the hands of every developer*. https://aws.amazon.com/machine-learning/

Breuer, H., Fichter, K., Lüdeke-Freund, F., & Tiemann I. (2018). Sustainability-oriented business model development: Principles, criteria, and tools. *International Journal of Entrepreneurial Venturing*, *10*(2), https://doi.org/10.1504/IJEV.2018.10013801

Calatayud, A., Mangan, J., & Christopher, M. (2019). The self-thinking supply chain. *Supply Chain Management: An International Journal*, *24*(1). https://doi.org/10.1108/SCM-03-2018–0136.

Christopher, M. (2016). *Logistics and Supply Chain Management*. Pearson.

Doligalski, T. (b.r.). *Platformy wielostronne, rynki wielostronne, multisided markets*. Blog o e-biznesie i marketingu internetowym. https://www.doligalski.net/multi-sidedmarkets/

European Commission. (2019). Communication from the Commission European Green Deal, COM(2019) 640 final, Brussels, 11.12.2019. https://eur-lex.europa.eu/legal-content/PL/TXT/HTML/?uri=CELEX:52019DC0640&from=DE (20.10.2022).

Fundacja Ellen MacArthur. (2015). *Ku gospodarce o obiegu zamkniętym: Biznesowe uzasadnienie przyspieszonej zmiany*.

Garay-Rondero, C. L., Martinez-Flores, J. L., Smith, N. R., Caballero Morales, S. O., & Aldrette-Malacara, A. (2020). Digital supply chain model in Industry 4.0. *Journal of Manufacturing Technology Management*, *31*(5), 887–933. https://doi.org/10.1108/JMTM-08-2018-0280

Geissbauer, R., Schrauf, S., Schneider, J., & Hermans, M. (2020). *Connected and autonomous supply chain ecosystems 2025*. PwC.

Hausner, J. (2020). Odporność i inwestowanie we współczesnej gospodarce rynkowej. In: J. Hausner, & W. Paprocki (Eds.), *Inwestycje i odporność gospodarcza – wyzwania dla Polski*. Publikacja Europejskiego Kongresu Finansowego.

Komisja Europejska (2015). *Otoczenie regulacyjne platform i pośredników internetowych, przetwarzania danych, chmur obliczeniowych i gospodarki współpracy*. Konsultacje publiczne, 24.09.2015.

Kulczycka, J. (2020). Gospodarka o obiegu zamkniętym – wyzwanie i odpowiedzialność. In: *Biznes na rzecz zmiany 2019/2020*. Centrum UNEP/GRID.

Kulczycka, J. (Ed.). (2020). *Wskaźniki monitorowania gospodarki o obiegu zamkniętym*. Instytut Gospodarki Surowcami Mineralnymi i Energią PAN.

Lee, K.-F. (2018). *AI Superpowers: China, Silicon Valley, and the New World Order*. Houghton Mifflin Harcourt. https://doi.org/10.1086/703271

Moazed, A., & Johnson, N. L. (2016). *Modern monopolies: What it takes to dominate the 21st Century Economy*. St. Martin's Press.

Nowicka, K. (2016). Cloud computing – warunek sine qua non sharing economy. In: M. Poniatowska-Jaksch, & R. Sobiecki (Eds.), *Sharing Economy (gospodarka współdzielenia)*. Oficyna Wydawnicza SGH.

Nowicka, K. (2019). *Technologie cyfrowe jako determinanta transformacji łańcuchów dostaw*. Oficyna Wydawnicza SGH.

Nowicka, K. (2020a). Customer Experience as the driving force for supply chain digital transformation. *European Journal of Economics and Business Studies*, *6*(1). https://doi.org/10.26417/ejes.v6i1.p6-15

Nowicka, K. (2020b). Supply Chain Management in the Access Economy Environment. *e-Mentor*, (2/84).

Nowicka, K. (2021a). Circular economy values perspective on digital supply chains business models. In: A. Pluta-Zaremba, & A. Szelągowska (Eds.), *Economics of Sustainable Transformation*. Routledge.

Nowicka, K. (2021b). Platforms in Supply Chain Management: Disruption or evolution? In: T. Doligalski, M. Goliński, & K. Kozłowski (Eds.), *Disruptive platforms: markets, ecosystems, monopolists*. Routledge. https://doi.org/10.4324/9781003207481

Nowicka, K. (2023). Digital supply chains and the development of the circular economy (part I). *Gospodarka Materiałowa i Logistyka*, (1), 1–6. https://doi.org/10.33226/1231-2037.2023.1.1

Nowicka, K. (Ed.), (2022a). Gospodarka w obiegu zamkniętym. Część 1. Przedsiębiorstwo, instytucje, miasto. Oficyna Wydawnicza SGH.

Nowicka, K. (Ed.), (2022b). *Gospodarka w obiegu zamkniętym. Część 2. Łańcuchy dostaw*. Oficyna Wydawnicza SGH.

Nowicka, K., & Szymczak, M. (2020). Łańcuchy dostaw i logistyka w obliczu czwartej rewolucji przemysłowej. In: K. Marchewka-Bartkowiak, & M. Korolewska (Eds.), Gospodarka, rynek i państwo wobec rewolucji technologicznej. *Studia Biura Analiz Sejmowych*, (3). https://doi.org/10.31268/studiabas.2020.22

OECD. (2019). *An introduction to online platforms and their role in the digital transformation*. OECD Publishing. https://doi.org/10.1787/53e5f593-en

Pawłowicz, W. (2017). Sztuczna inteligencja wkracza na rynek masowy. *Computerworld*, 06.06.2017. https://www.computerworld.pl/news/Sztuczna-inteligencja-wkracza-na-rynek-masowy,408144.html

Śledziewska, K., & Włoch, R. (2020). *Gospodarka cyfrowa. Jak nowe technologie zmieniają świat*. Wydawnictwo Uniwersytetu Warszawskiego. https://doi.org/10.31338/uw.9788323541943

Szymczak, M. (2015). *Ewolucja łańcuchów dostaw*. Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu.

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Head of the Department of Logistics and Head of Postgraduate Studies Logistics and Supply Chain Manager at the SGH Warsaw School of Economics. She specializes in supply chain management and the impact of digital technologies on the competitiveness of the supply chain. In addition to her scientific involvement, she cooperates with the European Commission as an expert for the evaluation of H2020 and HE projects. She was the manager of the international ChemMultimodal project implemented under the Interreg Central Europe Program in 2016–2019. Currently, in the NAWA Strategic Partnerships program (Academic Partnership in the field of methods and applications of advanced data analysis), prof. Nowicka, in cooperation with Loyola University Chicago Quinlan School of Business, is implementing a project on advanced business analytics in supply chains and logistics management. She is also the head of research financed from the subsidy of the Ministry of Education and Science for the SGH Warsaw School of Economics in the years 2022–2024 on the circular economy and the issues of circular supply chains. Prof. Nowicka has over 30 years of practical experience enabling her to share knowledge in the field of supply chain management and logistics with both business and students. Her research interests include e-business supply chain management, circular supply chain management and the sustainability impact of the digital supply chain. She is the author of over 150 publications – articles in Polish and foreign scientific journals, book chapters, monographs and expert opinions.

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Kierownik Katedry Logistyki oraz kierownik Studiów Podyplomowych „Menedżer logistyki i łańcuchów dostaw" w Szkole Głównej Handlowej w Warszawie. Specjalizuje się w zarządzaniu łańcuchem dostaw i wpływie technologii cyfrowych na konkurencyjność łańcucha dostaw. Oprócz zaangażowania naukowego współpracuje z KE jako ekspert ds. ewaluacji projektów H2020 i HE. Była kierownikiem międzynarodowego projektu ChemMultimodal, zrealizowanego w Programie Interreg Central Europe w latach 2016–2019. Obecnie, w programie NAWA Partnerstwa Strategiczne (partnerstwo akademickie w zakresie metod i zastosowań zaawansowanej analizy danych), prof. Nowicka we współpracy z Loyola University Chicago Quinlan School of Business realizuje projekt dotyczący zaawansowanej analityki biznesowej w łańcuchach dostaw i zarządzaniu logistyką. Jest również kierownikiem badań finansowanych z subwencji MEiN dla SGH w latach 2022–2024 na temat gospodarki o obiegu zamkniętym i problematyki cyrkularnych łańcuchów dostaw. Prof. Nowicka ma ponad 30 lat praktycznego doświadczenia umożliwiającego jej dzielenie się wiedzą z zakresu zarządzania łańcuchem dostaw i logistyką zarówno z biznesem, jak i ze studentami. Jej badania naukowe obejmują zarządzanie łańcuchem dostaw w e-biznesie, zarządzanie łańcuchem dostaw w obiegu zamkniętym i wpływ cyfrowego łańcucha dostaw na zrównoważony rozwój. Jest autorką ponad 150 publikacji – artykułów w czasopismach naukowych polskich i zagranicznych, rozdziałów w książkach, monografii i ekspertyz.