The self-report presenting a description of scientific activities and achievements of

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Contents

1. Name

Grażyna Kędzia

2. Diplomas, degrees conferred in specific areas of science

2010 PhD diploma in economics in the field of management sciences awarded by the Council of the Faculty of Management of the University of Lodz, 21.06.2010, based on the presented doctoral thesis pt. "Risk management in supplier-buyer relationships on the B2B market", prepared under the scientific supervision of dr hab. Maciej Urbaniak, prof. UŁ (Appendix – Z2). Reviewers: dr hab. J. Sosnowski, prof. UŁ i dr hab. M. Szymczak, prof. UEP.

2005 Master's degree obtained on June 29, 2005, confirmed by a diploma of completion of five-year full-time master's studies in Environmental Protection, at the Faculty of Biology and Environmental Protection of the University of Lodz. Studies completed with very good results. Master's thesis title: "Verification of the DALIS Mathematical Model version 1.0 for the Sulejów Reservoir".

Supplementary education – postgraduate studies

2007, Certificate of completion of one-year postgraduate studies in "Cosmetology", Faculty of Biotechnology and Food Sciences, Lodz University of Technology.

2006, Diploma of completion of one-year postgraduate studies entitled "Occupational health and safety", Faculty of Process and Environmental Engineering, Lodz University of Technology.

Supplementary education – selected diplomas and certificates

2023, Certificate of participation in the training entitled "Sustainability reporting in line with CSRD and ESRS", EY Academy of Business.

2023, Certificate of participation in the training entitled "Life cycle assessment – LCA. What exactly is the environmental impact of the product?", Bureau Veritas.

2021, Diploma of completion of training entitled "Packaging design workshop using the Design Thinking method", Brandy Lab and the Institute of Industrial Design in Warsaw.

2019, "Business Continuity Management Systems (BCMS) Auditor/Lead Auditor ISO 22301:2012" Certificate, BSI Training Academy, Warsaw.

2019, Certificate of participation in the workshop entitled "How to write and develop systematic literature review", conducted by prof. Justin Paul (Rollins College, Florida, University of Porto Rico Graduate School of Business, USA), Knowbase Centrum Jakości Badań Naukowych, Faculty of Management, University of Lodz.

2017, "BSCI: APICS CPIM – Basics of Supply Chain Management" Certificate, 17/12/2017 (positive exam result).

2017, Certificate of participation in statistical workshops, Knowbase Centrum Jakości Badań Naukowych, Faculty of Management, University of Lodz.

2016, Certificate of participation in "Statistical Workshops", Knowbase Centrum Jakości Badań Naukowych, Faculty of Management, University of Lodz.

2016, Certificate of completion of the English course at level B2+, with a very good result.

2016, Certificate of participation in MS Excel training, Knowbase Centrum Jakości Badań naukowych, Faculty of Management, University of Lodz.

2015, Certificate of participation in the training entitled "Nvivo - an example of a qualitative data analysis program", Knowbase Centrum Jakości Badań Naukowych, Faculty of Management, University of Lodz.

2015, Certificate of participation in the training entitled "Expert in writing applications for project co-financing from ESF funds", EVIKA Ewelina Sikora.

2013, PRINCE2 certification and PRINCE Foundation training certificate, APMG International.

2013, Certificate of participation in the training entitled "Settlements and reporting in research and development projects", University of Lodz.

2011, Course completion certificate "Basis of Supply Chain Management", MPM Productivity of APICS, 25-27/05/2011

2011, Certificate of participation in the training entitled "Professional Purchasing Management", MPM Productivity Management.

2011, CE/EMAS/sem/45/06/2011 certificate of participation in a seminar under the patronage of the Chancellery of the Prime Minister, entitled "EMAS eco-management and audit system in public administration", Systemy Zarządzania ALMAT.

2010, Certificate 36/2010/R on participation in the training entitled "Establishing and running a spin off spin out business", Foundation „Fundusz Inicjatyw".

2009, Manager of Occupational Health and Safety Management Systems according to the requirements of the OHSAS 18001:2007 specification, LRQA.

2008, Certificate No. 8 DA/PC-32-2/2008 from participation in the training entitled "Business Continuity Management", Polskie Centrum Badań i Certyfikacji S.A.

2007, Diploma of completion of an international course entitled „Sustainable Baltic Region", The Baltic University, A Regional University Network.

2006, Diploma of completion of an international course entitled „Baltic Sea Environment", The Baltic University, A Regional University Network.

2006, Certificate No. 620/S/06 Internal auditor. Occupational Health and Safety Management System, Det Norsk Veritas.

2006, TELC „Deutch fur Beruf" Certificate.

2005, TELC "Zertyfikat Deutch" Certificate.

3. Information on employment in research institutes or faculties/ departments

since 01.10.2011 – present, assistant professor at Department of Logistics, Faculty of Management, University of Lodz (former Department of Quality Management).

01.10.2010 – 30.09.2011, assistant professor with a doctoral degree at the Department of Quality Management, Faculty of Management, University of Lodz.

01.10.2007 – 30.09.2010, assistant at the Department of Quality Management, Faculty of Management, University of Lodz.

4. Presentation of the achievements referred to in Article 219 para. 1 point 2 of the Act of 20 July 2018 Law on Higher Education and Science (Journal of Laws of 2021, item 478, as amended)

4.1 Scientific achievement constituting the basis for applying for the degree of habilitated doctor

As a scientific achievement, within the meaning of Article 219 para. 1 point 2 of the Act of 20 July 2018 Law on Higher Education and Science (Journal of Laws of 2021, item 478, as amended), which is a significant contribution to the development of social sciences in the discipline of management and quality science, I point out the publication series entitled:

Supplier involvement in product development as an opportunity to build supply chain resilience and reduce the negative impact of supply chains on the natural environment

4.2 Publications included in the scientific achievement

The series includes eight publications prepared after obtaining a doctoral degree, including: five scientific articles in English published in scientific journals, one scientific article published in peer-reviewed conference materials indexed in Web of Science, one chapter in a monograph and one monograph in Polish.

The series concerns the issues of supply chain management of manufacturing companies that, operating in the modern VUCA (Volatility, Uncertainty, Complexity, Ambiguity) world, are looking for effective strategies and practices in anticipating and responding to economic, environmental, and social disruptions to value addition processes. Such a strategy may become, the *Supplier Involvement in Product Development* (SIPD).

The cycle includes:

1. Wieteska, G. (2018). The domino effect – disruptions in supply chains, *LogForum*, 14(4), 495-506.
2. Wieteska, G. (2018). Design of resilient supply chains [in]: Studzieniecki, T., Kozina, M., Alilovic, D., S. (ed.), *Economic and Social Development. Book of Proceedings ESD 2018*, 571-578.
3. Wieteska, G. (2019). How to measure the supplier involvement?, *Gospodarka Materiałowa i Logistyka*, 8, 29-39.
4. Wieteska, G. (2020). How to measure SCRES? – the perspective of flexibility and redundancy in relationships with suppliers, [w:] A. Michałkiewicz, W. Mierzejewska (ed.), *Contemporary organisation and management. Challenges and trends*, University of Lodz, Lodz, 173-201.
5. Wieteska, G. (2020). The impact of supplier involvement in product development on supply chain risks and supply chain resilience, *Operations and Supply Chain Management-An International Journal*, 13(4), 359-374.
6. Kędzia, G. [1] (2022). *Dostawca w procesie produktu*, University of Lodz, Lodz, ss. 282.
7. Kędzia, G. [70%], Staniec I. [30%], (2022). The impact of supplier involvement in product development on supply chain resilience: the mediating role of communication, *International Journal for Quality Research*, 16 (4), 973-998.
8. Kędzia, G. (2024). The ambiguous impact of supplier involvement in product development on supplier relationship resilience and company performance, *Central European Management Journal*, 32 (2), 233-261.

The series of publications is the result of research on supplier-buyer cooperation in the product development process in an era of growing environmental turbulence. The research was financed by a grant I received from the National Science Center [Appendix II.9.B.1.] and as part of research grants for young scientists [Appendix II.15.D.1].

Four out of five scientific articles in the presented series were published in journals that obtained the following Impact Factor in 2023 according to Journal Citation Reports:

- *LogForum* – 1.2
- *International Journal for Quality Research* – 1.2
- *Central European Management Journal* – 1.3
- *Operations and Supply Chain Management-An International Journal* – 2.4

All research assumptions presented in the publications included in the series were developed by me independently. One of the articles [pub. 7] was written with a co-author who enriched the analysis of quantitative data with advanced statistical knowledge in the field of taking into account the

[1] In 2022 year I changed my last name into Kędzia.

mediating variable in structural modeling. A detailed description of the authors' contributions to this article is included in the co-author statements [Appendix I.7.A and Appendix I.7.B].

4.3. Discussion of the purpose and research results of the publication series

4.3.1. Justification of the choice of research area and identified research gaps

The series of publications presents issues embedded in management and quality sciences. It mainly concerns the topic of supply chain management, which is part of the subdiscipline: logistics management (Cyfert et al., 2014). At the same time, it also refers to two other subdisciplines, i.e. strategic management and innovation management (Bełz et al., 2023).

The considerations presented in the self-report are based on the definition that defines supply chain management as the management of relationships with suppliers and buyers, aimed at providing the highest value to the client (Christopher, 2005, p. 5), taking into account the process approach (Supply Chain Council, 2012, p. 3; Lambert and Schwieterman, 2012) and the integration approach, which indicates the existence of in-depth contacts and relationships between the supply chain links (Szymczak, 2004, p. 30; Świtała, Niestrój and Hanus, 2017). Relationships, on the other hand, are the activities and resources of enterprises that - interconnected within the framework of a given cooperation - determine the achievement of the goals of both parties (supplier and buyer), while also interacting with other entities in the network (Wieteska, 2011, p. 61).

Striving to strengthen their position on the market, companies make efforts to improve their portfolio, both by developing new products (New Product Development, NPD) and introducing modifications to the products currently offered (Product Development, PD) [2]. This is important regardless of the type of supply chain management strategy implemented, although it is considered essential for innovation-driven supply chains. The common denominator of these efforts is the successive involvement of various stakeholders in research and development work as part of the open innovation model, where knowledge flows and ideas are shared in a planned manner (Chesbrough, 2003, p. 43; Enkel, Gassmann and Chesbrough, 2009), or even creating a network of relationships in the form of an open innovation ecosystem (Mielcarek, 2016; Klimas 2019). In addition to customers, whose requirements and expectations must be met first, suppliers are most often involved in the product development process (Sopińska and Mierzejewska, 2017, p. 105).

The subject of the presented research is the relationships between: supplier involvement in product development, supply chain risk, supply chain resilience, supplier relationship resilience, and company performance.

The product development process in the supply chain involves both strategic and operational-level subprocesses. Planning and organizing connections with suppliers and customers are particularly crucial for their success (Croxton et al., 2001). An integrated supplier-buyer system

[2] In my self-report, I use one term, i.e. "product development process", keeping both situations in mind.

enables the realization of a product within a transformation process that encompasses various phases of value creation (Blaik, 2010, p. 184). Decisions regarding supply chain integration and building relationships with suppliers involved in the product development process aim to achieve the highest level of maturity and establish strategic partnerships characterized by long-term collaboration, trust, and the mutual complementarity of specific competencies and assets (Van Weele, 2014, p. 355). It is important to develop a product strategy tailored to the company's needs and capabilities, with the goal of maintaining or enhancing the competitiveness of the offer. Such a strategy appropriately directs the work of the product development team, supports functional integration within the company, facilitates the assignment of detailed tasks, and drives the search for innovative solutions (Kotler et al., 2002, p. 667).

The direction of product improvement can be guided by the so-called maturity criterion of the applied technology (incremental innovation, market innovation, technological innovation, original innovation) and the criterion of the type of technical innovations (product innovations and process innovations) (Rutkowski, 2011, pp. 112-113). The contemporary definition of innovation largely relies on the classical understanding of the concept as presented by Schumpeter (1960, p. 104) and Drucker (1992, p. 42). Product offering enhancement occurs in relation to the successive levels of a given product. A key activity that can significantly determine a company's competitive advantage is the development of so-called potential products, which represent a future, modified, and often new form resulting from the implementation of specific improvements and innovations (Kotler and Keller, 2017, p. 350).

The characteristics of a product determine the structure of the network and the nature of the relationships between its participants (Ülkü and Schmidt, 2011). The Bill of Materials (BOM) list developed in companies, which includes the components needed for the production of a given product along with quantities and lead time (LT) information, significantly supports supply chain mapping (Arnold, Chapman, Clive, 2012, pp. 80-84). The architecture and novelty of the product, type of demand, and production environment influence not only the structure of the supply chain (e.g., complexity and number of tiers in the upstream and downstream) but also the type of lean/agile/leagile strategy implemented in supply chain management (Witkowski, 2010, p. 59; Ciesielski, p. 56; Arnold, Chapman, and Clive, 2012, p. 57). Given the significant link between the product and supply chain configuration (Fixson, 2005; Pashaei and Olhager, 2015), it is interesting **to explore the importance of the product development process for supply chain design when other stakeholders, such as suppliers, are involved in this process.** In light of contemporary challenges, the presented research delves deeper into this question by examining the relationship between the product development process, supplier involvement in product development, and the building of resilient (disruption-resistant) supply chains, as well as the creation of supply chains with a reduced negative impact on the natural environment. The starting point for these considerations

was the issue of risk management in the supply chain, which was the subject of my doctoral dissertation.

The main types of risk causing disruptions in supply chains are considered to be supply risk, demand risk, operational risk within the enterprise, and external risk, including political, economic, social, technological, legislative, and environmental factors (Manuj and Mentzer, 2008; Pfohl, Gallus, and Thomas, 2011; Wieteska, 2011, p. 77; Huth and Düerkop, 2019; Świerczek, 2020, p. 106; Yildiz Ozenc, Er, and Firat, 2023). Numerous studies have confirmed that a disruption in one area of the supply chain can negatively impact another area (Jüttner, 2005; Venkatesh et al., 2015; Chen, Reniers, and Khakzad, 2020; Ivanov, 2020; Hartwick et al., 2023). This occurs due to the interdependencies between resources, activities, and participants in the supply chain (Hertz, 2006; Christopher and Holweg, 2011; Bygballe, Dubois, and Jahre, 2023; Colon and Hochrainer-Stigler, 2023). The product development process is a particularly important process in the supply chain, as it initiates the sequential approach to creating and delivering value to the customer, preceding procurement, production, and distribution (Kotler, 2005, p. 111; Barney, 2014, pp. 127-128). Given its position and the complexity of the structure and relationships within the supply chain system (Świerczek, 2020, pp. 58-65), I assumed that it can significantly impact the continuity of other processes carried out within it. Since the subprocesses conducted within the product development process are most closely related to customer relationship management and supplier relationship management (Croxton, 2001), it can also be assumed that this process also significantly affects business continuity for both customers and suppliers. Against this backdrop, a fundamental question arises about **how often and for what reasons the product development process is disrupted, and how the effects of these disruptions impact other supply chain processes and other supply chain participants.**

In the face of the need to anticipate and respond to the increasing number of external and global threats in the 21st century (e.g., financial crises, climate change and natural disasters, international migrations), supply chain resilience (SCRES) has become the subject of intensive scientific research. A particularly important issue addressed by researchers is the identification of strategies and practices that effectively support building SCRES (e.g., Christopher and Peck, 2004; Bhamra, Dani, and Burnard, 2011; Roberta Pereira, Christopher, and Lago Da Silva, 2014; Hohenstein et al., 2015; Tukamuhabwa et al., 2015; Kamalahmadi and Parast, 2016; Ali, Mahfouz, and Arisha, 2017; Datta, 2017; Ribeiro and Barbosa-Povoa, 2018; Świerczek, 2020, pp. 211-277; Shishodia et al., 2023). The importance of this issue is immense, especially today when supply chains face multidimensional problems caused by unknowable unknowns/black swan events, whose risks cannot be managed due to the lack of knowledge and awareness that they could occur (Gil, 2001, pp. 105-107; Browning and Ramasesh, 2015; Paltrinieri, Comfort, and Reniers, 2019; Lu and Shen, 2020; Feduzi et al., 2021), such as the COVID-19 pandemic or the war in Ukraine (Weber, 2021; Chen et al., 2023; Kyriazis and Corbet, 2024).

Since continuous and stable development requires companies to effectively anticipate and respond to the increasing volatility, uncertainty, complexity, and ambiguity of the contemporary business environment, there is also a focus on the connections and necessity of integrating the management of sustainable supply chains with decisions aimed at enhancing their resilience to economic, environmental, and social disruptions (e.g., Ramezankhani, Torabi, and Vahidi, 2018; Zavala-Alcívar, Verdecho, and Alfaro-Saiz, 2020; Singh, Hamid, and Garza-Rey, 2023; Negri, Cagno, and Colicchia, 2024). Recently, in-depth research conducted by me (in collaboration with scholars from the University of Szczecin) has shown that the implementation of external and internal sustainable development practices determines the building of supply chain resilience before, during, and after a disruption. This means that these practices affect the ability of supply chains to anticipate risks, respond to disruptions, and recover and learn after a disruption has occurred (Tundys, Kędzia, Wiśniewski, and Zioło, 2024, pp. 166-168)[3].

Supplier relationship management is now a particular challenge for supply chain managers. As demonstrated by many years of experience, working with suppliers can be a source of increased risk, which, if materialized, leads to problems with maintaining the continuity of procurement, production, and distribution processes (e.g., Sheffi, 2001; Chopra and Sodhi, 2004; Haraguchi and Lall, 2015; Cai and Luo, 2020; Rowan and Laffey, 2020; Gupta, Ivanov, and Choi, 2021; Khurshid et al., 2024). Since the terrorist attack on the World Trade Center, there has been significant attention paid to risk management, security, and business continuity in supplier relationships, including in our country (e.g., Brdulak, 2007; Konecka, 2010; Łupicka, 2011; Klosa, 2013; Kramarz and Kramarz, 2013; Jedynak, 2015; Myszak and Sowa, 2016; Kochański, 2017; Szymczak, 2017; Kulińska and Giera, 2019; Świerczek, 2019; Wasilewski, 2019; Komańda and Klosa, 2020; Marzantowicz, Nowicka and Jedliński, 2020; Cyplik and Zwolak, 2022; Grzybowska and Tubis, 2022; Kauf, 2022; Tundys, 2022).

Although collaboration with suppliers can be perceived as a source of increased risk, companies choose to enhance the level of supply chain integration by Supplier Involvement in Product Development (SIPD). The most advanced approach in this regard is Early Supplier Involvement (ESI). This involves engaging partners in the initial stages of the product development process (i.e., during idea generation, idea selection, and concept development), in supply chain planning processes (Sales and Operations Planning, S&OP), and even in the improvement of production systems (Kähkönen, Lintukangas, and Hallikas, 2015). ESI is focused on integrating decisions related to product design, process design, and supply chain design (Petersen, Handfield, and Ragatz, 2005).

Supplier involvement, especially in the early stages of the product development process, is a decision of strategic importance. Such collaboration is long-term and partnership-oriented, engaging various functions (e.g., strategic sourcing, production, marketing) and resources (both tangible and

[3] In the mentioned quantitative study, we used the results of my research on SCRES, presented in pub.2 and pub.5.

intangible) from both parties (Carr and Pearson, 2002; McIvor and Humphreys, 2004). Involving suppliers in product development positively impacts company performance (Najafi Tavani et al., 2013; Flynn, Huo, and Zhao, 2010; Feng et al., 2014). Moreover, companies view this involvement as an opportunity to reduce design costs, improve product and process quality, and shorten the time to market for new products, with the reality of these benefits confirmed by numerous studies (e.g., Hoegl and Wagner, 2005; Johnson and Filippini, 2009; Incekara and Koçak, 2017). Despite the fact that strategic supplier-buyer collaboration is based on mutual trust and commitment, it is important not to overlook the strong interdependencies that pose a significant source of increased risk (Wieteska, 2014).

In the literature, there are publications that recognize the role of supplier collaboration during product development for managing supply chain risk. However, these are very few and predominantly present qualitative research. Zsidisin and Smith (2005) connected selected Early Supplier Involvement (ESI) practices with minimizing supply risk in one of the Rolls-Royce divisions in their case study. Tang, Zimmerman, and Nelson (2009) observed that during the development of the Boeing 787 aircraft, it is possible to influence the impact of different types of risks on the designed supply chain. Meanwhile, Roberta Pereira, Christopher, and Lago Da Silva (2014), based on a systematic literature review, identified procurement actions in supply chain management and supplier-buyer relationship management that could be significant for creating supply chain resilience. **However, it remains unclear whether and how integrating the product development process with procurement and supplier relationship management process determines supply chain resilience. It is also uncertain what role supplier involvement in product development plays in strengthening supply chain resilience and which SIPD practices should be implemented to effectively respond to business environment uncertainty and risk.** Therefore, there is **a theoretical gap** in this area. Filling this gap will allow for the identification of opportunities resulting from involving suppliers in product development, especially in light of the need to create a resilient and sustainable supply chain from the product design stage.

In addition to the theoretical gap, there is also a significant **empirical gap**. My systematic literature review on the supplier involvement in product development[4] has revealed two fundamental research challenges. The first challenge is **to understand the relationship between supplier involvement in product development and supply chain resilience (including the resilience of relationship with involved suppliers), as well as the relationship between supplier involvement in product development and supply chain risk.** The second challenge **is to investigate the potential for shaping supply chains with a reduced negative impact on the natural environment through collaboration with suppliers in the product development process.**

[4] SLR included 170 scientific articles from scientific databases: EBSCOhost, Scopus, Science Direct, Emerald, Wiley Online Library (pub.6).

The first research gap relates to the lack of quantitative studies that would confirm the existence of relationships between the identified variables. It is known that one of the fundamental areas for building supply chain resilience is supplier relationship management (Fantazy, Kumar, Kumar, 2009). Additionally, practices that enhance process flexibility and resource redundancy are considered crucial for building resilient supply chains (Mackay, Munoz, Pepper, 2020). The second research gap led me to conduct especially a qualitative study. The starting point was the research by Pujari (2006), who observed that the market success of ecological product innovations depends, among other factors, on involving suppliers in product development. This was complemented by the research of Saunders et al. (2015), who noted that early involvement of strategic suppliers and leverage suppliers could lead to better environmental and social outcomes in New Product Development projects. Given the increasing focus on Sustainable Supply Chain Management and the Circular Economy, studies on company collaboration **to minimize the negative environmental impact of value-adding processes through *Design for Environment* (DfE) approach** are becoming particularly interesting[5].

Since there is a lack of operationalization and measurement methods for the supplier relationship resilience in management sciences, and the methods previously used to measure Supplier Involvement in Product Development were not the result of a systematic literature review, there is also a methodological gap. Developing measurement methods is crucial for validating the hypotheses and theoretical models I have constructed for the planned research, as well as for future studies conducted by other researchers in these areas.

In light of contemporary crises, there is also an **application gap**. Addressing this gap involves providing supply chain managers with a list of Supplier Involvement in Product Development practices which implementation will enhance supply chain resilience. Additionally, it involves delivering detailed descriptions (case studies) of collaboration with suppliers in the product development process, focused on implementing environmental sustainability principles in supply chain management and closing the product lifecycle in line with the Circular Economy.

The **focus of my research** is on the supply chains of manufacturing companies. This choice is driven by several reasons. First, manufacturing firms are typically central nodes with crucial experience and knowledge in coordinating multi-level collaboration with supply chain stakeholders in product development. Second, the predominant perspective in existing research on Supplier Involvement in Product Development has been the dyadic supplier- manufacturer relationship, with the manufacturer (customer) as the respondent (Kędzia, 2022, p. 80). In this way, I aimed to ensure the continuity of the cognitive process initiated by other researchers at an international level and to

[5] The following approaches are distinguished within Design for Environment (Fixel, 2009): A. Design for detoxification including: Design for release reduction, Design for hazard reduction, Design for benign waste deposition B. Design for revalorization, including: Design for product recovery, Design for product disassembly, Design for recyclability C. Design for capital protection and renewal, including: Design for human capital, Design for natural capital, Design for economic capital - their integration can be interpreted as Design for sustainability.

address the research gaps identified during my systematic literature review on SIPD. Additionally, I focused on sectors where companies offer products characterized by complexity and innovation. It has been noted that such companies are more likely to involve suppliers in the product development process, engaging partners from the early stages (Mikkola and Skjoett-Larsen, 2003; Spaulding and Woods, 2006; Parker, Zsidisin, and Ragatz, 2008).

4.3.2. Research problem, research questions and research objectives of the publication series

The main research problem that has served as the starting point for this publication series is the insufficient understanding of the significance of the product development process and the purchasing process, as well as the strategy of supplier involvement in product development in effectively responding to increasing uncertainty and risk in supply chains, including emerging global crisis and challenges.

To address this research problem, five explanatory and exploratory research questions were posed:

Q1: What are the causes, epicenters, and directions of the impacts of the most severe disruptions in supply chains?

Q2: What is the role of the product development process and the purchasing and supplier relationship management process in building supply chain resilience?

Q3: What is the current state of knowledge and key research gaps regarding supplier involvement in product development?

Q4: How do manufacturing companies operating in the Polish market involve suppliers in product development?

Q5: How should companies collaborate with suppliers during product development to build supply chain resilience and reduce the negative environmental impact of supply chains?

Against the background of identified research gaps and posed research questions, the main goal of the publication series was to identify and examine the possibilities of building resilient supply chains and shaping supply chains with a reduced negative impact on the natural environment by involving suppliers in product development. Its implementation required in-depth studies of theoretical, methodological and empirical aspects, which is why it was necessary to formulate specific objectives for three layers: cognitive theory, methodological and application:

I. Cognitive Theory Objectives:

Ct1: Conceptualization of the domino effect in the supply chain.

Ct2: Determination of the role of the product development process in disruptions occurring in supply chains.

Ct3: Identification of the assumptions and scope of supply chain resilience concept.

Ct4: Understanding the significance of integrating the product development process with the purchasing and supplier relationship management process for shaping supply chain resilience.

Ct5: Conceptualization of the supplier relationship resilience.

Ct6: Identification of current directions, results, and conclusions from research on supplier involvement in product development.

Ct7: Identification of practices and decisions accompanying manufacturing companies operating in the Polish market, during supplier involvement in product development.

Ct8: Understanding managers' opinions on the impact of involving suppliers in product development on sustainability risk.

Ct9: Identification of Design for Environment approaches used in collaboration with suppliers in the product development process.

Ct10: Identification of opportunities to reduce the negative environmental impact of supply chain processes, during product development in collaboration with suppliers.

Ct11: Understanding the impact supplier involvement in product development on supply chain risk and resilience.

Ct12: Identification of the impact of communication with suppliers during product development on supply chain resilience and company performance.

Ct13: Understanding the impact of supplier involvement in product development on the resilience of relationship with those suppliers and on company performance.

II. Methodological Objectives

Cm1: Development of a measurement method for supplier involvement in product development (observable variables, measurement scales, constructs).

Cm2: Development of a measurement method for the supplier relationship resilience (observable variables, measurement scale, constructs).

Cm3: Development of a measurement method for supply chain risk (observable variables, measurement scales, constructs) and company performance (observable variables, measurement scale, construct).

Cm4: Construction of a structural equation model for supplier involvement in product development, supply chain risk, and supply chain resilience.

Cm5: Construction of a structural equation model for supplier involvement in product development, supply chain resilience, and company performance.

Cm6: Construction of a structural equation model for supplier involvement in product development, the resilience of relationship with involved suppliers, and company performance.

III. Application Objectives

Ca1: Raising awareness among managers about the phenomenon of disruption spreading in the supply chain process approach.

Ca2: Identifying purchasing decisions made during the product development process that impact the attributes of a resilient supply chain.

Ca3: Modeling the motivators, activators, and barriers to supplier involvement in product development in relation to the multidimensional outcomes of SIPD projects.

Ca4: Providing managers with practices of involving suppliers in product development that are significant for reducing supply chain risk and building supply chain resilience.

Ca5: Providing managers with knowledge about the importance of communication in collaboration with suppliers during product development for strengthening supply chain resilience and improving company performance.

Ca6: Identifying practices of involving suppliers in product development that are significant for building supplier relationship resilience and improving company performance.

Ca7: Providing case studies on supplier involvement in product development focused on reducing the negative environmental impact of supply chain processes.

Given that the strategy of involving suppliers in product development concerns supplier-buyer relationships, and thus the associated resources and activities of partners within that cooperation, the research was conducted based on *resource-based theory* and *resource dependence theory*. I assumed that building a competitive advantage by a manufacturing company is enabled by its unique resources and their configuration. The company's decisions to involve other supply chain stakeholders in the product development process are determined by its need for external resources, such as raw materials, financial capital, or knowledge. This approach may increase the company's vulnerability to external environment, intensifying its dependence on external resources. In the case of supplier involvement in product development, this will be most of all, the dependence on supplier resources.

4.3.3. Methods used in the research process

The multi-faceted scientific research approach grounded in management sciences, which I presented in the publication series, required the application of **systematic and sequential inductive-deductive reasoning** along with **abductive reasoning** (Ciesielski, 2014; Kovács & Spens, 2005; Eriksson & Engström, 2021). Based on this logic, I planned and conducted an exploratory-explanatory process of scientific inquiry.

Addressing the research problem and achieving the interdisciplinary research objectives necessitated the use of triangulation at the methodological level (Konecki, 2000, p. 86; Stanisławski, 2017). I conducted **multi-stage research using mixed methods**, including the **development and validation of scales** and **measurement models**. The methods employed encompassed both **qualitative and quantitative approaches.**

All the publications in the series included **critical literature reviews**, which served as the fundamental basis for achieving the cognitive theory objectives. In some of these publications, I employed the method of **Systematic Literature Review** (SLR), incorporating **structured review**, **framework-based review**, and **bibliometric review** (pub.1, pub.2, pub.3, pub.4, pub.6), as well as **desk research** (pub.2, pub.6). Among the qualitative methods, I utilized **In-Depth Interviews** (IDI) (pub.2, pub.4, pub.6) and the **case study** method (pub.2, pub.6). These methods allowed for the exploration, understanding, and acquisition of new information about the phenomena under study. Consequently, they enriched the research process and contributed to both cognitive and practical effectiveness (Pilch & Bauman, 2010, pp. 297-300; Matejun, 2011; Bednarowska, 2015; Olejnik, Kaczmarek & Springer, 2018, pp. 113-138; Stępień, 2022). As part of the quantitative methods, I employed the **CATI technique** (Computer-Assisted Telephone Interviewing) for data collection using a questionnaire, what provided the opportunity to reach the targeted group of respondents and obtain necessary data (pub.1, pub.5, pub.6, pub.7, pub.8), as well as **statistical analysis** (pub.1, pub.6) and **structural modeling** (pub.5, pub.7, pub.8). The analysis of numerical data through these quantitative methods enabled the identification of new cause-and-effect relationships and the verification of the hypotheses posed (Kauf, 2004, pp. 114-144; Kaniewska-Sęba, Leszczyński & Pilarczyk, 2006, pp. 113-114; Tłuczak & Kauf, 2015, pp. 39-75; Kolasińska-Morawska, 2021, pp. 95-122; Czakon, 2021, pp. 73-93).

The systematic literature review (SLR) method I used in:

- Publication 1 („SLR 1") – a four-stage procedure (following Tranfield, Denyer, and Smart, 2003), a framework-based review (Stępień, 2023, p. 16), applied databases: EBSCOhost Online Research Databases, Emerald Insight. The main research question: What is the current understanding on the issue of the supply chain domino effect?
- Publication 2 („SLR 2") – a four-stage procedure (following Tranfield, Denyer, and Smart, 2003), a framework-based review (Stępień, 2023, p. 16), applied databases: EBSCOhost Online Research Databases, Scopus, Emerald Insight, Wiley Online Library. The main research question: What are the main SCRES determinants?
- Publication 3 („SLR 3") – a four-stage procedure (following Tranfield, Denyer, and Smart, 2003; Kamalahmadi and Parast, 2016), a framework-based review (Stępień, 2023, s. 16), applied databases: EBSCOhost Online Research Databases, Scopus, Emerald Insight, Wiley Online Library. The main research question: How scientists measured the supplier involvement in product development so far? Five sub-questions: What are the names of SI constructs? From what number of items are SI constructs built? To what refer the SI constructs' items? What are the similarities between the content of constructs? What variables appeared in the research articles on SI in addition to full constructs?

- Publication 4 („SLR 4") – expanding "SLR 2", a four-stage procedure (following Tranfield, Denyer, and Smart, 2003; Kamalahmadi and Parast, 2016), a framework-based review (Stępień, 2023, s. 16), applied databases: EBSCOhost Online Research Databases, Scopus, Emerald Insight, Wiley Online Library. Four main research questions: What is the understanding of flexibility and redundancy in the context of supply chain resilience strategies? What are the resilient practices for building flexibility and redundancy in supply chains? How has flexibility and redundancy been measured so far in the studies related to the SCRES concept? What are the best resilient practices for building flexibility and redundancy in relationships with suppliers?
- Publication 6 („SLR 5") – expanding "SLR 4", a four-stage procedure (following Czakon, 2013, p. 52; Tranfield, Denyer and Smart, 2003, p. 207-222), hybrid review, i.e. combining a structured review, a framework-based review and a bibliometric review (Stępień, 2023, s. 16), applied databases: EBSCOhost Online Research Databases, Scopus, Emerald Insight, Wiley Online Library. The main goal of the study was to determine the current state of knowledge about SIPD and to address four main research questions: How is the supplier involvement in product development defined? What research areas are present in the existing international literature on supplier involvement in product development? What factors influence the supplier involvement in product development? What research gaps can be identified in the area of SIPD studies?

The CATI technique I used in my research presented in:

- Publication 1 („CATI 1") – The study involved 202 manufacturing companies. The sampling frame was the "Rzeczpospolita" 500 list and the Bisnode Database. The questionnaire, refined during the pilot study, consisted of seven groups of questions related to business continuity management in the supply chain. Two filtering questions were used during the selection of companies, and respondents were required to have at least three years of experience as a supply chain manager in the same workplace.
- Publication 5, 6, 7 and 8 („CATI 2") – The study involved 500 manufacturing companies from several PKD sections, specifically 25, 26, 27, 28, 29, and 30 (Główny Urząd Statystyczny, 2017, p. 44). The sample size selection for each section adhered to the principle of representativeness, using the quota sampling method (Kauf, 2004, p. 69). The statistical sample included 10,051 organizations. The selection of sections was driven by the need to assess the collaboration of companies offering a relatively diverse portfolio, including highly complex and innovative goods. The questionnaire[6], improved during the pilot study,

[6] The testing of questionnaires for "CATI 1" and "CATI 2" was comprehensive and served multiple purposes: verifying the research problem (whether the selected research problem is applicable to the given population), verifying the research tool (whether the questionnaire is developed correctly at the methodological, substantive,

consisted of 22 questions corresponding to eight research questions regarding supplier involvement in product development. One filtering question was used during company selection, and the respondent was required to be responsible for at least one product development project in the surveyed company that involved a supplier. If necessary (due to insufficient knowledge of the respondent), more than one representative from a given company was to be included in the study.

The IDI method I used in the research presented in:

- Publication 2 („IDI 1"): an in-depth, semi structured interview (Olejnik, Kaczmarek and Springer, 2018, p. 113), with a representative of the manufacturing company who has knowledge of purchasing and supplier relationship management and the cooperation in the product development chain.
- Publication 4 („IDI 2-8"): seven in-depth, semi structured interviews (Olejnik, Kaczmarek and Springer, 2018, s. 113), with representatives of manufacturing companies from various sectors. The respondents were employees with key knowledge of supplier relationship management. Contact with the companies and data collection were conducted through direct, telephone, and online methods (Kaniewska-Sęba, Leszczyński, and Pilarczyk, 2006, p. 112), also with the support of a marketing research agency. The eighth interview taken into account in publication 4 was "IDI 1".
- Publication 6 („IDI 9-14"): six structured interviews (Olejnik, Kaczmarek i Springer, 2018, s. 113), with representatives of manufacturing companies from various sectors. The selection of the sample was purposeful. The surveyed companies are enterprises of various sizes operating in Poland, carrying out research and development work to which they engage their suppliers. The respondents were top-level employees, i.e. presidents, company owners or managers with appropriate knowledge and experience in the field of SIPD. Contact with companies and data collection took place by telephone and online (Kaniewska-Sęba, Leszczyński and Pilarczyk, 2006; p. 112), as well as directly, but also with the support of a marketing research agency, due to the very difficult situation resulting from the ongoing COVID-19 pandemic.

The case study method I used in the research presented in:

- Publication 2 („case study 1"): the subject of the study was the product development chain, i.e. cooperation of the manufacturing company (large, international company with foreign

interactive and technical level), verifying the practical aspects of conducting the study (duration, appropriate selection of the sampling frame), and verifying the analytical potential of the research tool (assessing the feasibility of performing analyses, the usefulness of indicators). The pilot study resulted in shortening the length of the questionnaire (eliminating certain questions) and refining the areas that posed the difficulty for respondents.

capital) with suppliers (first and second tier) and the main customer. The data collection method was an in-depth, semi structured interview („IDI 1") (Olejnik, Kaczmarek and Springer, 2018, p. 113) and desk research („ADZ 1"), which included websites and business reports of participants in the studied supply chain.

- Publication 6 („case study 2-7"): the subject of the study was the cooperation of manufacturing enterprises with suppliers in the product development process. The data collection method was structured interview „IDI 9-14" (Olejnik, Kaczmarek and Springer, 2018, p. 113) and desk research („ADZ 2"), which included websites and business reports of participants in the studied supply chain as well as normative documents.

The statistical analysis and structural equation modeling I used in the research presented in:

- Publication 1 („statistical analysis 1") – the source of quantitative data was a quantitative study „CATI 1". The analysis included the calculation of basic statistical parameters, i.e. percentage of indications and average rank.
- Publication 5 („SEM 1") – the source of quantitative data was a quantitative study „CATI 2". To confirm the reliability and validity of the developed constructs, Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA) were used. Structural Equation Modeling (SEM) was applied to evaluate "theoretical model I", which ultimately determined the construction of the empirical model of the impact of SIPD on supply chain resilience and company performance, as well as the verification of hypotheses H1-H4.
- Publication 6 („statistical analysis 2") – the source of quantitative data was a quantitative study „CATI 2". The analysis included the calculation of basic statistical parameters, i.e. percentage of indications and average rank, median.
- Publication 7 („SEM 2") – the source of quantitative data was a quantitative study „CATI 2". To confirm the reliability and validity of the developed constructs, Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA) were used. Structural Equation Modeling (SEM) was applied to evaluate "theoretical model II", which ultimately determined the construction of the empirical model of the impact of SIPD on supply chain resilience and company performance, as well as the verification of hypotheses H5-H7.
- Publication 8 („SEM 3") – the source of quantitative data was a quantitative study „CATI 2". To confirm the reliability and validity of the developed constructs, Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA) were used. Structural Equation Modeling (SEM) was applied to evaluate "theoretical model III", which ultimately determined the construction of the empirical model of the impact of SIPD on the resilience of the relationship with the involved supplier and company performance, as well as the verification of hypotheses H8-H12.

4.4.4 Discussion of the publications included in the publication series

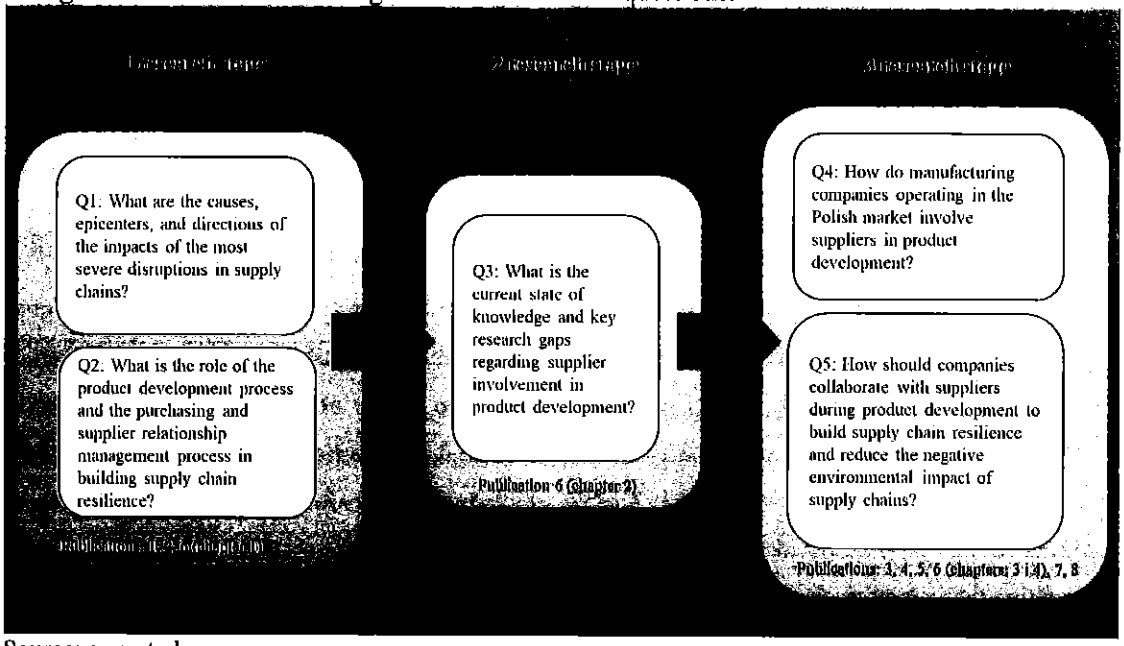
In conducting qualitative and quantitative research and developing the publications in the thematic series, I progressively implemented a three-stage research plan. This plan aimed to investigate the significance of collaborating with suppliers in product development in the face of two key challenges for contemporary businesses: addressing the increasing uncertainty and risk in supply chains, and responding to the growing environmental pollution problems.

In the first stage of the research, I identified the sources of the most significant disruptions and the directions in which the effects of these disruptions spread within supply chains from a process perspective. I was interested in the functioning of supply chains of manufacturing companies in relation to uncertainty and risk, as well as identification of the processes that serve as the most common epicenters of disruptions within supply chains. I was particularly interested in identifying epicenters that had not been sufficiently addressed in previous research. Since one of these epicenters turned out to be product development process, I subsequently focused on three aspects. First, I examined the contemporary definition and role of the product development process within the value chain and its significance in designing the supply chain. Second, I wanted to understand the scope of the concept and definition of supply chain resilience. Third, I attempted to determine how the product development process might influence supply chain resilience. Observing that purchasing decisions made within this process could be crucial, I then directed my attention to the issue of supplier involvement in product development, which integrates the product development process with purchasing and supplier relationship management.

The second stage of the research involved a systematic literature review on supplier involvement in product development. I identified the current state of knowledge on this topic, and the key research gaps. I attempted to fill these gaps in **the third stage of research**. I developed missing methods for measuring the studied phenomena and verified three original theoretical models, thanks to which I examined the relationships between: the supplier involvement in product development, the supply chain resilience, the resilience of relationship with involved suppliers, supply chain risk and company performance. I also prepared case studies presenting partnership cooperation with suppliers in the product development process, aimed at reducing the negative impact of supply chain processes on the natural environment.

Against the background of three research stages and five main research questions, the eight main publications were prepared, the connection of which within a thematic cycle is presented in Figure 1.

Figure 1. A diagram presenting the connection of publications in publication series, against the background of three research stages and main research questions.



Source: own study

Below, in table number 1, a summary of the main research results from the publication series is presented.

Table 1. Synthetic presentation of main research results against the background of detailed research objectives and research methods used.

No.	Publication's title	Detailed research objectives	Research methods	Mian research results
1	The domino effect – disruptions in supply chains	Cognitive theory objectives: „Ct1" „Ct2" Application objective: „Ca1"	Qualitative method: „SLR 1" Quantitative methods: „CATI 1", „ statistical analysis 1"	• There is a research gap regarding research on the domino effect in supply chains. • I defined the domino effect in the supply chain. • A domino effect occurred in 95% of the supply chains surveyed, and any supply chain process could become the epicenter of disruption. The effects of a disruption in one process may affect other company processes and other participants in the supply chain. • The most seriously disrupted processes in the researched supply chains are: 1. Production and logistics of production 2. Demand management 3. *Development and commercialization of products* 4. Purchasing and supplier relationship management. • The main cause of disruption in the product development process is the strategic risk taken by companies. • Supplier and customer processes are most often affected by disruptions in the purchasing and supplier relationship management process. • The main causes of the most serious disruptions of supply chain processes are: 1. Macro environment that negatively affected the company 2. Operational risk which source was the company 3. Operational risk which source was another participant in the supply chain
2	Design of resilient supply chains	Cognitive theory objectives: „Ct3" „Ct4"	Qualitative methods: „SLR 2", „IDI 1", „ADZ 1",	• The concept of supply chain resilience is presented in the literature in the form of a number of definitions and frameworks that include phases, strategies, stages, capabilities and practices (np. Christopher i Peck,

		Application objective: „Ca2"	„case study 1"	2004; Ponomarov i Holcomb, 2009; Kamalahmadi i Parast, 2016; Roberta Pereira, Christopher i Lago Da Silva, 2014; Hohenstein i inni, 2015; Tukamuhabwa i inni, 2015; Ali, Mahfouz i Arisha, 2017). • The attributes of a resilient supply chain are: flexibility, redundancy, transparency and visibility, agility, collaboration and information sharing. However, *flexibility and redundancy are key attributes.* • The resilience of the supply chain can be shaped already in the product development process, by the impact of purchasing decisions (in a favorable or unfavorable way) on the structure, processes and resources of the supply chain, especially in the area of relationships with suppliers (Table 2). • Integration of the product development process with the purchasing and supplier relationship management process takes place in projects involving suppliers in product development. • The success of cooperation with suppliers in the product development process depends on appropriate communication. • One of the important directions for improving the product offer by companies is the application of the Design for Environment.
3	How to measure the supplier involvement?	Methodological objective: „Cm1"	Qualitative method: "SLR 3"	• I proposed a method for measuring the supplier involvement in product development. • I developed three proposed constructs for SIPD: degree of supplier involvement, partnership practices, communication (Figure 5). • In the proposed constructs, I included 26 measurable variables, which constitute a list of good practices in the field of cooperation with suppliers in the product development process, which can be used by supply chain managers.
4	How to measure SCRES? – the perspective of flexibility and redundancy in relationships with suppliers	Cognitive theory objective: „Ct5" Methodological objective: „Cm2"	Qualitative methods: „SLR 4", „IDI 1", „IDI 2-8"	• Flexibility and redundancy are key to each phase of disruption and SCRES strategy. A good practice used by many authors is to include them in the same study and treat them as complementary elements. • Therefore, I proposed a method for measuring the supplier relationship resilience in terms of flexibility and redundancy. • I developed four proposed constructs: supplier flexibility, procurement flexibility, logistics flexibility and redundancy (Figure 10). • In the proposed constructs, I included 33 measurable variables, which constitute a list of good practices aimed at strengthening the supply chain resilience in the area of cooperation with suppliers, which can be used by supply chain managers.
5	The impact of supplier involvement in product development on supply chain risks and supply chain resilience	Cognitive theory objective: „Ct11" Methodological objectives: „Cm1", „Cm3", „Cm4" Application objective: „Ca4"	Quantitative methods: „CATI 2", „SEM 1"	• I developed a theoretical model to test the impact of SIPD on supply chain risk and supply chain resilience (Figure 4). • I constructed and verified four hypotheses based on the literature on risk in SIPD, supply chain risk and SCRES: H1. Supplier involvement in product development reduces a company's operational risk H2. Supplier involvement in product development reduces supply risk H3. A company's reduced operational risk positively impacts supply chain resilience H4. Reduced supply risk positively impacts supply chain resilience. • I have developed my own measurement methods (constructs, observed variables, measurement scales) for supplier involvement in product development, supply risk and operational risk in the enterprise. Supply chain resilience I expressed with a construct

				adapted from another author's study (Ponomarov 2012, p. 76), which description is consistent with the SCRES definition used in my study (pub.2). • I confirmed the reliability and validity of the constructs, i.e. degree of supplier involvement in product development (DSI), partnership practices during supplier involvement in product development (PSI), communication during supplier involvement in product development (CSI), supplier risk (SR) and operational risk (OR). • I constructed an empirical structural equation model for supplier involvement in product development, supply chain risk, and supply chain resilience (Figure 6). • I recognized that SIPD reduces the supply chain risk and indirectly strengthens the supply chain resilience. • I confirmed that SIPD, characterized by mutual willingness to develop a long-term relationship, sharing cost information and technical/ technological knowledge, mutual supporting in the improvement, cross-functional teams, reduces the risk of untimely deliveries, risk of poor technical quality of deliveries and risk of quantitative non-compliance in deliveries. • I recognized that in order to reduce operational risk in an enterprise, particular importance should be given to communication in the supplier-buyer relationship in the product development process. Consequently, reduced operational risk has a positive impact on SCRES.
6	Dostawca w procesie rozwoju produktu	Cognitive theory objectives: „Ct6", „Ct7", „Ct8", „Ct9", „Ct10" Application objectives: „Ca3", "„Ca7"	Qualitative method: „SLR 5", „IDI 9-14", „ADZ 2", „case studies 2-7" Quantitative methods: „CATI 2", „ statistical analysis 2"	• The issue of the product development process is well described in both Polish and foreign literature on the subject. • The implementation of the product development process involves various functions of a manufacturing company, especially cooperation with suppliers. The integration of the product development process and the purchasing process and supplier relationship management takes place at the strategic and operational level. • *Design for...* approaches used in the product development process impact other supply chain processes. The most holistic perspective of product design is the perspective of the entire product life cycle. In this case, in addition to value addition processes, the product use stage and the product disposal stage are also taken into account. In turn, product disposal stage determines the possibility of closing the product life cycle in accordance with the principles of circular economy. • I conducted a systematic review of the literature on SIPD, which included bibliometric analysis and content analysis of 170 scientific publications from scientific databases: EBSCOhost, Scopus, Science Direct, Emerald, Wiley Online Library. • The bibliometric analysis was carried out according to a number of criteria (e.g. year of publication, research method), and its results were used to design the "CATI 2" study. • The content analysis of the articles was collected in seven main thematic areas, and its results were also used to design the "CATI 2" study. • I identified and presented in a model approach the SIPD determinants, i.e. drivers, barriers, enabling factors, as well as the effects of SIPD projects (Figure 3). • A systematic review of the literature on the subject allowed for the identification of three key research

				gaps, which became the reason for constructing and conducting a quantitative ("CATI 2") and qualitative study ("IDI 9-14"). • I recognized how manufacturing companies operating on the Polish market involve suppliers in product development. • I recognized the principles of eco-design that companies implement in the product development process in cooperation with suppliers. • I have developed six case studies that constitute good practices of B2B (*business to business*) cooperation in SIPD eco-projects. Each project concerns a different process of the closed product life cycle (according to the circular economy), i.e. supply of raw materials, design, production, distribution, use and disposal of the product. • I have developed a list of recommendations for manufacturing companies that want to achieve better results in the product development chain.
7	The impact of supplier involvement in product development on supply chain resilience: the mediating role of communication	Cognitive theory objective: „Ct12" Methodological objectives: „Cm3", „Cm5" Application objective: „Ca5	Quantitative methods: „CATI 2", „SEM 2"	• I developed a theoretical model to test the impact of SIPD partnership practices and communication during SIPD on supply chain resilience and company performance (Figure 7). • I constructed three hypotheses (next in the publication series) based on the literature on communication during SIPD, supply chain resilience and company performance in SIPD: H5. There is a statistically significant direct effect of partnership practices during SIPD on SCRES H6. There is a statistically significant indirect effect of partnership practices during SIPD on SCRES through communication (CSI) as a mediating variable H7. There is statistically significant direct effect of SCRES on company performance. • I used my own constructs and measurement scales in the model, i.e. partnership practices during SIPD and communication during SIPD. Supply chain resilience I expressed with a construct adapted from another author's study (Ponomarov 2012, p. 76), which description is consistent with the SCRES definition used in my study (pub.2). • To measure the company performance, I have developed my own measurement method (construct, observable variables, measurement scale) (pub.3). For this purpose, I used literature presenting the effects of SIPD. • An empirical structural equation model was constructed presenting a significant indirect impact of SIPD partnership practices on SCRES through communication (CSI), which is a mediating variable, and on company performance (Figure 8). • I recognized that partnership practices implemented during SIPD strengthen SCRES, but by ensuring frequent, intensive and conducted in a friendly atmosphere, especially direct supplier-buyer communication. Further, increased supply chain resilience has a positive impact on the company performance, i.e. net profit, sales growth, lead time for fulfilling customers' orders and customer satisfaction.
8	The ambiguous impact of supplier involvement in product developm	Cognitive theory objective: „Ct13" Methodological objectives: „Cm2", „Cm6"	Quantitative methods: „CATI 2", „SEM 3"	• I developed a theoretical model to test the impact of SIPD on the resilience of the relationship with the involved supplier and the company performance (Figure 9). • I constructed and verified five hypotheses (next in the publication series) based on the literature on SIPD, SCRES and supplier relationship management in the face of uncertainty and risk, flexibility and redundancy

	ent on supplier relationship resilience and company performance	Application objective: „Ca6"		in relationship with suppliers, and company performance in SIPD: H8. Supplier involvement in product development, understood as the degree of supplier involvement in product development, partnership practices and communication with the involved supplier increases the flexibility of the relationship with the involved supplier H9. Supplier involvement in product development, understood as the degree of supplier involvement in product development, partnership practices and communication with the involved supplier decreases redundancy in the relationship with the involved supplier H10. Supplier involvement in product development, understood as the degree of supplier involvement in product development, partnership practices as well as communication with involved supplier, positively impacts company performance H11. Increased flexibility of relationship with involved supplier positively impacts company performance H12. Decreased redundancy in relationship with involved supplier positively impacts company performance. • In the model, I used my own developed and confirmed constructs and measurement scales: supplier involvement in product development and company performance (pub.5 and pub.7). • I confirmed the reliability and validity of the constructs developed by me, i.e. supplier flexibility (SF), procurement flexibility (PF), logistics flexibility (LF) and redundancy (RED). • I constructed an empirical structural equation model for supplier involvement in product development, supplier relationship resilience, and company performance (Figure 11). • I recognized that SIPD impacts the supplier relationship resilience and the company performance. • I confirmed that partnership practices during SIPD increase procurement flexibility, and communication during SIPD increases supplier flexibility and procurement flexibility. • I confirmed that partnership practices during SIPD reduce redundancy in the relationship with the involved supplier. • I confirmed that partnership practices during SIPD impact company performance. • I confirmed the indirect impact of communication during SIPD on the company performance if the mediating variables are: supplier flexibility and procurement flexibility. • I confirmed the impact of increased supplier flexibility and increased procurement flexibility on the company performance. • I have not confirmed the impact of reduced redundancy on the company performance.

4.4.5. Summary and main conclusions formulated on the basis of the publication series

The summary and main conclusions from the publication series are presented below, in accordance with the cause-and-effect approach, the use of which was critical to maintaining the continuity of the cognitive process. I carried out three stages of research in a constellation of five research questions and subsequently formulated detailed research objectives.

Stage 1: "The product development process is one of the most disrupted processes and the cause of the domino effect in supply chains. The product development process can impact the supply chain resilience through purchasing decisions made in it, which directly affect relationships with suppliers"[7]

Although the term "domino effect" is widely used in business practice, it has not received sufficient attention in scientific research on supply chains („SLR 1"). So I made an attempt to develop a scientific definition of it[8]. It was then used to design a quantitative study ("CATI 1"), in which I identified the most frequently disrupted processes and the impact of these disruptions on other supply chain processes[9]. The results of the survey confirmed that the key types of supply chain risk are: supply risk, operational risk and demand risk (Manuj and Mentzer, 2008; Pfohl et al. 2011, Wieteska 2011, p. 61). Moreover, they showed that **(pub.1)**:

- In addition to the production process (31.19%) and logistics of production (13.86%), the demand management process (10.89%) and the purchasing and supplier relationship management process (7.92%), the most common epicenter of the most serious disruptions in supply chains is the **process of product development and commercialization**[10] (8,42%).
- Disruptions to the product development process most strongly disrupt the production process, while disruptions to the production process most strongly disrupt the order fulfillment process in the business to business (B2B) market.
- The main causes of disruptions in the product development process are: strategic risk and changing factors of the company's macro-environment, as well as operational risk the source of which is the company or another participant in the supply chain.

These three main observations became the input for subsequent work, in which I focused on recognizing the role of the product development process in supply chain design. I started with considerations deepening the contemporary definition of the product development process in the value chain. They became the source of the following observations, which I then used to continue the research process **(pub.6, chapter 1)**:

- Over the last four decades, the planning and organization of research and development work have evolved from the simplest systems of activity of individual company functions to mature, very well-systematized activities that are high-value investments in which more than one organization is involved, especially direct suppliers. This reorientation results, among

[7] The bolded content is the short title of stage 1, which indicates the main conclusions.
[8] I defined the domino effect in the supply chain as: „"a situation, driven by the supply chain complexity and supplier-client dependencies, in which the effects of risk spread along the value adding processes affecting more than one supply chain link and hindering their performance temporarily".
[9] In the study, I used the process approach presented in the Global Supply Chain Forum (GSCF) model.
[10] In publication 1, I used the term *development and commercialization of products process*. In subsequent research, In subsequent research, I decided to introduce the term *product development process* because this term dominates the literature on SIPD.

others, from: the high pace of technological changes, shortening product life cycles and new legal regulations in the field of Sustainable Development (SD) and Circular Economy (CE).

- Product development activities are the starting point for creating value in the chain of relationships between clients and suppliers.
- Product development can integrate various functions in a manufacturing enterprise. However, the leading role is played by the **integration of the product development process with the purchasing and supplier relationship management process.** It covers both the strategic level (identification of criteria for segmentation and evaluation of suppliers, selection of suppliers, development of guidelines for cooperation and including them in contracts, definition of the process measurement system) and the operational level (recognition of opportunities for cooperation with suppliers, development of a communication plan with suppliers, performance measurement).
- *"Design for.."* approaches used in the product development process combine the product design with the design of its value chain processes. By using the relationships that exist between the product (its features, architecture, innovativeness) and the supply chain configuration (its structure, processes and resources), they can enable enterprises to implement the economic, environmental and social goals of the supply chains. The leading contemporary approaches are pro-environmental approaches, i.e. Design for Environment (DfE) and Design for Circular Economy (DfCE).

Then, I conducted a systematic literature review on supply chain resilience, in which **(pub.2)**:

- I identified the latest SCRES definition, which became my guide when constructing further research[11].
- I analyzed the available frameworks and identified the main attributes of a resilient supply chain, which are: flexibility, redundancy, transparency and visibility, agility, collaboration and information sharing.

Continuing qualitative research on SCRES (pub.4). I recognized that **flexibility and redundancy are core and complementary attributes of resilient supply chains, often studied simultaneously** (e.g. Datta et al., 2007; Manuj and Mentzer, 2008; Parast and Shekarian, 2019). I also identified that flexibility and redundancy are key for supply chains in every phase of disruption (Figure 2):

- In the *pre-disruption phase*, which requires the implementation of a *proactive* strategy to build supply chain resilience, flexibility and redundancy should be appropriately planned in

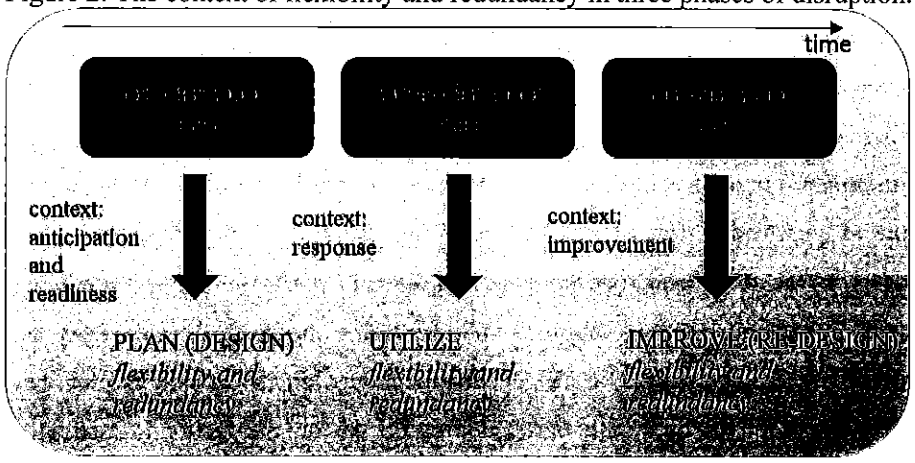
[11] SCRES „is a dynamic process of steering the actions so that the organisation always stays out of danger zone, and if the disruptive/uncertain event occurs, resilience implies initiating a very rapid and efficient response to minimise the consequences and maintaining or regaining a dynamically stable state, which allows it to adapt operations to the requirements of the changed environment before the competitors and succeed in the long run" (Datta 2017).

relation to anticipated risks and uncertainties causing disruptions in the supply chain. Therefore, their consideration can be started already at the moment of designing the product and its supply chain.

- *During disruption* phase, which requires the implementation of a *concurrent* strategy to build supply chain resilience, flexibility and redundancy are used to ensure the functioning of the supply chain in a crisis situation.
- In *post disruption* phase, which requires a reactive strategy to build supply chain resilience, flexibility and redundancy are improved in the process of reconfiguring the supply chain in response to post-disruption experiences and lessons learned.

Finally, in order to observe potential connections between the product development process and supply chain resilience, I conducted an in-depth interview ("IDI 1") and developed "case study 1", which focused on the Product Development Chain of a large, international packaging manufacturer. I was interested in the manufacturer's cooperation with suppliers and customers in the packaging development process against the background of the identified SCRES attributes (pub.2).

Figure 2. The context of flexibility and redundancy in three phases of disruption.



Source: own study **(pub.4)**.

As a result, I recognized that **supply chain resilience can be shaped already in the product development process**. This happens as a result of a number of **purchasing decisions made therein, which determine the SCRES attributes, especially in relation to cooperation with suppliers** (Table 2).

Table 2. Summary of SCRES attributes and purchasing decisions made in the product development process.

SCRES element	Purchasing decisions in NPD determining the SCRES element
Flexibility	Decisions on: sourcing strategy (single/double), supplier location (distance, country), supplier selection criteria (e.g. flexibility, capability)
Redundancy	Decisions on: back-up suppliers, safety stock, safety lead time
Transparency and visibility	Decisions on: tools for mapping supply chain structure and flows, traceability, availability of information about supply chain structure
Agility	Decisions on: supply chain strategy, internal integration, IT tools
Collaboration	Decisions on: the length of contracts, frequency of communication, communication channels, co-location, developing experience and knowledge of cooperating employees, code of conduct.
Information sharing	Decisions on: the type of shared information, communication tools, frequency of exchanging information.

Source: own study **(pub.2)**.

I also identified that these decisions may be beneficial or disadvantageous in terms of building supply chain resilience, especially in terms of flexibility and redundancy in relationships with suppliers. For example, for small and medium-sized packaging development projects, a single sourcing strategy is selected, while at the same time expecting high production and product flexibility from a given supplier (including pro-environmental improvements, such as the use of recycled raw materials or reducing the weight and size of packaging).

Single sourcing is the recommended strategy for SIPD (Asmus and Griffin, 1993). However, it is subject to an increased risk of loss of continuity of supply in a crisis situation. Namely, it may mean a reduction in purchasing flexibility (Norrman and Jansson, 2004). Larger packaging development projects, on the other hand, determine the adoption of a double sourcing strategy, which allows for the switching orders between suppliers and increasing the production capacity of the supplier base. Moreover, SIPD projects in the examined supply chain do not involve having emergency suppliers due to the too high costs of developing the desired production infrastructure at suppliers and too long supplier integration time in the product development process. This means giving up this kind of redundancy in relationships with suppliers.

Stage 2: „New research gaps can be identified in research on supplier involvement in product development"[12]

Since the integration of the product development process with purchasing and supplier relationship management process takes place when collaborating with suppliers during product development, I decided to identify the current state of knowledge on supplier involvement in product development and related key research gaps. Therefore, the next stage of the research was to conduct a systematic literature review on supplier involvement in product development **(pub. 6, chapter 2)**.

[12] The bolded content is the short title of stage 2, which indicates the main conclusion.

Selected **results from the bibliographic analysis** of collected publications, that were used to design the quantitative study ("CATI 2") are:

- The research method preferred by the authors is a survey.
- Most studies used a two-sided perspective, i.e. supplier-customer (manufacturer) cooperation, in which the respondent is the manufacturer.
- Some authors took the perspective of examining the involvement of many suppliers in the product development process, while others took the perspective of cooperation with one (key) supplier. I decided to use the second perspective in my research, wanting to deepen my knowledge of practices implemented in a single relationship and moving away from the traditional understanding of flexibility in relationships with suppliers, i.e. having multiple sources of supply.
- Most of the publications were written by authors representing one country. Among the 26 countries, most publications were authored by scientists from the United States of America, but there were no publications by scientists from our country and no results concerning our country.

The content analysis of the collected publications resulted in the identification of seven main thematic areas. I described each of the areas in detail in the monograph, in relation to the results and conclusions from previous research, the methods of measuring variables used in them and the identified relationships between variables. Main **results from the content analysis** of collected publications, that were used to design the "CATI 2" quantitative study are as follows for the following areas:

The essence and way of involving suppliers in product development

The analysis of the definitions regarding the supplier involvement in product development allowed the conclusion that SIPD should be understood as "the supplier's participation in the (new) product development process, being the involvement of its tangible and/or intangible resources at any stage, but precisely specified moment by the customer". Joint development work can begin already in the initial stages of NPD. This type of Early Supplier Involvement (ESI) is related to the increased role of supplier in decision-making and allows for the integration of activities in the field of product design, project design and supply chain design.

Product attributes and supplier involvement in product development

A review of research on products developed in collaboration with suppliers has revealed that the two main product characteristics considered in SIPD studies are: the architecture of the developed component/final product (e.g., complexity, modularity) and the novelty/innovation of the developed component/final product. These factors primarily influence the timing of supplier involvement in product development and the outcomes of the product development project. Specifically, greater complexity, novelty, and technological uncertainty prompt companies to engage suppliers earlier in

the process. Additionally, SIPD occurs more frequently in the high-tech sector, and supplier integration yields better results, especially for incremental product innovations.

Selection and assessment of suppliers

The initial and periodic assessment of the involved suppliers is of particular importance for the success of SIPD. Making a decision to involve a supplier in product development means taking into account many preliminary criteria. They concern both the supplier itself (e.g. its knowledge, credibility, production capabilities) and the features of potential cooperation (e.g. mutual trust, partner's commitment). Enterprises prefer a single sourcing strategy and close proximity to the supplier involved in the product development process. Periodic assessment concerns, firstly, the assessment of the level of achievement of the assumed objectives assigned to joint development activities. Secondly, it verifies the effectiveness of suppliers in meeting qualitative and quantitative requirements at the stage of regular production.

Supplier-buyer portfolio models in the area of product development

The issue of product development holds a significant place in supplier-buyer relationship portfolio models. These models serve as a key source of guidelines for managing suppliers in the area of R&D. Despite the diversity of concepts, certain similarities can be observed in their construction logic and the aspects considered. Almost every approach classifies suppliers into four segments based on the type of goods supplied and the level of supplier involvement. The more experienced the supplier, the greater the autonomy it has in product and process design, as well as the earlier its involvement. Other segmentation criteria also emerge, such as development risk, which is highest when involving partners for strategic and critical goods. A strongly emphasized element in the models is also **communication** between partners during the design of products and processes. Researchers focus, among other things, on the frequency of contact and the types of communication channels used.

Features of the supplier-buyer relationship

In research on SIPD, the focus was on three main features of the supplier-customer relationship, i.e. **trust, commitment and dependencies**. Trust, especially mutual trust, is crucial for cooperation in the development process with a supplier and is one of the criteria for its selection. Commitment, including that of top management, largely determines the success of collaborative product development projects. In turn, the dependence of the company on the supplier increases in the case of ESI (when the partner's responsibility is greater) and with the degree of complexity of the purchased goods or the uniqueness of the supplier's technology. The dependency decreases when the product is modularized. However, low dependence on the supplier may, in turn, translate into better technical quality of the developed product.

Functional integration in the product development process

Broadly understood internal and external functional integration is also key to the success of cooperation in the product development process. The established development team should be co-

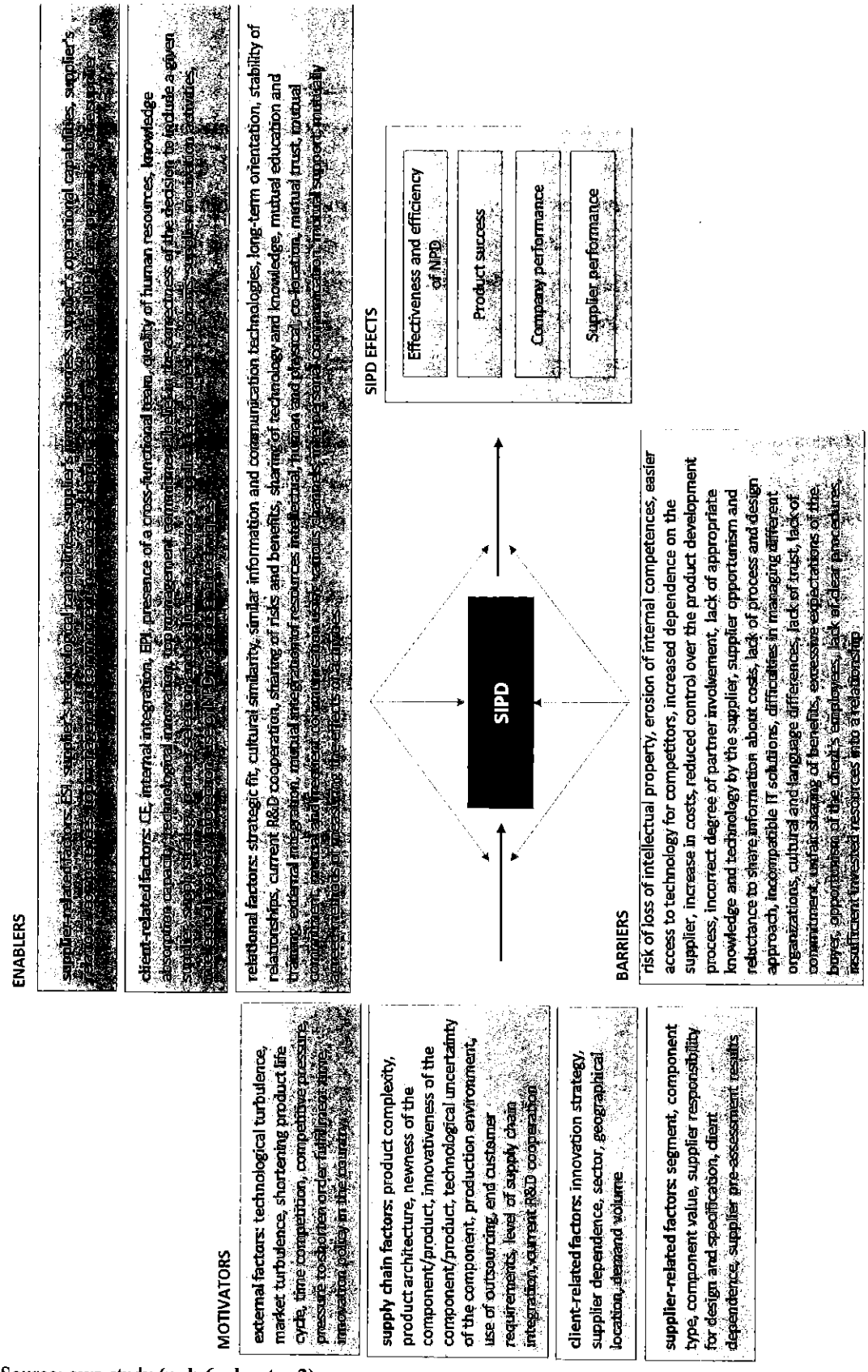
created by employees of both parties, characterized not only by technical knowledge, but also by social competences and the ability to use IT tools for multi-level communication in the supply chain. One of the best practices is also sharing a location.

Conditions for involving suppliers in product development

The summary of the content analysis of the articles was the determination of the conditions for involving suppliers in product development in the form of a model diagram (Figure 3). The inspiration for its development was the supply chain collaboration model constructed by Ralston, Richey and Grave (2017). The developed framework included four types of variables, i.e. **motivators, enablers, barriers and SIPD effects.** Among the motivators, I distinguished four groups, differing in their source of origin: external environment, supply chain, supplier, company (customer). The enabling factors included SIPD determinants and practices, which in turn positively influence the efficiency of supplier-customer cooperation. They include supplier-related factors, customer-related factors and relational factors. Barriers are the difficulties that can slow down and limit research and development in the product development chain. Expected results refer to the effectiveness and efficiency of the product development process, product success, as well as the supplier performance and the customer performance.

The presented scheme is a source of information for business practice on how to shape cooperation with suppliers when developing products in order to achieve the best possible results. The list of motivators are factors important from the point of view of the decision to implement a strategy of involving suppliers in product development. The enabler list is used to identify opportunities to drive SIPD from the perspective of the resources and skills of a given enterprise and its supply chain. The list of barriers, in turn, is an important input element for a comprehensive risk assessment in relation to the SIPD objectives, and then for taking appropriate risk control actions and achieving the best possible effects.

Figure 3. Model presentation of the conditions for involving suppliers in product development



Source: own study **(pub.6, chapter 2)**.

Key research gaps in the literature on the supplier involvement in product development

Bibliometric analysis and content analysis of the collected papers ("SLR 5") revealed the following key research gaps:

1. Lack of publications presenting the results detailed research on the involvement of suppliers in product development by enterprises operating on the Polish market, which constitutes a justification for conducting research in this area in our country
2. Lack of quantitative research results on the impact of supplier involvement in product development on the supply chain risk, supply chain resilience and supplier relationship resilience.
3. Lack of qualitative and quantitative research results on the possibilities of shaping supply chains with reduced negative impact on the natural environment, in cooperation with suppliers in the product development process.

Stage 3 „An attempt to fill key research gaps in the literature on supplier involvement in product development"[13]

An attempt to fill research gap number 1 – involving suppliers in product development by enterprises operating on the Polish market

The results of the quantitative study "CATI 2" provided valuable information regarding the involvement of suppliers in product development by companies operating in Poland. A summary of these results can be found in the following tables (Table 3-Table 7). The entities participating in the survey were small (34.4%), medium (40.2%), and large companies (25.4%) operating in our country. The surveyed organizations included those with domestic capital (87.2%) as well as foreign or mixed capital (12.8%), offering products for the domestic market (33.8%) or both the domestic and foreign markets (66.2%).

Table 3. Supply chains of the surveyed enterprises.

Type of strategy implemented in SCM	The dominant strategy of the surveyed companies (77.8%) was focused on adapting products to customer requirements and expectations, often the product is highly differentiated.
Performance	Almost all of the surveyed companies rated their net profit, sales growth, order cycle time, and customer service level as similar to or better than their competitors.

Source: own study **(pub.6, chapter 3).**

Table 4. Products developed in cooperation with suppliers.

Characteristics of products developed with suppliers	The studied product development projects most often characterized by a medium (38.8%) or high (50%) level of demand uncertainty (variability, difficulty in forecasting), medium level of architectural complexity compared to similar products (81%), and medium (74%) or high (19.6%) degree of variety, understood as the number of product variants. Most respondents stated that the total product delivery time was medium (63.8%) or short (25.8%). The developed product was assessed by the majority of

[13] The bolded content is the short title of the stage 2.

	respondents as having medium (59.2%) or high (33.2%) level of innovation, while the pace of technological change in the industry, which directly affects this product, was rated as medium (25.8%), high (46.8%), or very high (9.6%).

Source: own study **(pub.6, chapter 3)**.

Table 5. Suppliers involved in product development.

The tier at which the involved supplier is located	In each case, the surveyed companies indicated that the studied cooperation concerned the relationship: first-level supplier - buyer.
Characteristics of the good offered by the involved supplier and the supplier's market	Suppliers involved in product development offered goods of varying degrees of complexity. The difficulty of managing the purchase process was assessed by 70.8% of respondents as medium. Almost all companies (97.4%) indicated that the importance of purchasing these goods was at a medium or high level.
The location of the involved supplier	The involved partners were most often located in our country (91.4%).
Supplier initial assessment	Regardless of whether there was a previous business relationship with the supplier or not, almost all enterprises decided to perform at least a basic initial assessment of the partner, of which as many as 68% made the decision to engage the supplier based on detailed or very detailed data.
Supplier's responsibility for the specification of the offered good (compared to the company's responsibility)	As many as 84.2% of the surveyed enterprises declared that the supplier's responsibility for the specification of the goods purchased from him was greater or much greater than the company's responsibility.
The supplier's responsibility for the product development project compared to the responsibility of other involved stakeholders	The supplier's responsibility for the product development project was in most cases similar (59.2%) or greater (36.6%) than the responsibility of other involved stakeholders (e.g. customers, scientific and research institutions).

Source: own study **(pub.6, chapter 3)**.

Table 6. Features of the relationship between the involved supplier and the surveyed enterprise.

Length of cooperation with the supplier before involving partner in product development	Relationships with suppliers involved by the surveyed companies in the NPD process were mostly characterized by previous business experience - short (36.6%) or long (41%) cooperation. At the same time, companies declared that they had previously conducted SIPD projects with a given supplier - rarely (36.8%) or often (43.6%). Every fifth company has not previously cooperated with an involved supplier.
The company's involvement in a relationship with a supplier involved in product development	The vast majority of companies assessed their commitment to the relationship with the supplier involved in the product development as high, regardless of the reason, which can be: positive attitude towards cooperation (83.4%), the results of the cost-benefit assessment of cooperation (87.6%). Companies more often invested intangible resources (84.4%) than tangible resources (63%) in SIPD. Top management was also involved in cooperation in the development of products, which determined the companies' high or very high involvement (75.8% in total).
The company's dependence on the supplier	Most surveyed companies agreed or strongly agreed that company's dependence had emerged in SIPD. As many as 344 respondents (68.8%) believed that a success or crisis situation at the supplier could significantly affect the company's sales volume. At the same time, over 80% of the surveyed enterprises declared that changing the involved supplier would be very difficult for the company: it would mean high costs, and achieving the company's goals would not be possible. According to 90.6% of respondents, dependence on the supplier was related to, among others, a high volume of goods purchased from him.
The company's trust in the supplier	High trust in the supplier characterized almost all SIPD projects. Companies agreed or strongly agreed that trust in a supplier results from the belief in the supplier's friendliness and honesty (96%), technical/technological capabilities (96%), and that the partner will

	respond with understanding to problems/crisis situations company (96.6%), and that it will fulfill its obligations (99%).

Source: own study **(pub.6, chapter 3)**.

Table 7. Supplier involvement in product development.

The timing and degree of supplier involvement in product development	As many as 93.4% of the surveyed companies involved the supplier in the development process already at the idea generation stage. The greatest degree of supplier involvement also accompanied the initial stages of this process.
Partnership practices	Almost all companies (96%) declared that the relationships built with a supplier involved in product development were of a partnership nature. At the same time, the companies agreed with the statement that this cooperation was based on jointly set goals (94%), equitable risk and reward sharing (90.6%) and sharing physical assets, for example plant or equipment (72.6%). Every second company declared seeing a mutual desire to build a long-term relationship (53%), sharing knowledge (technical/technological) with the supplier (48%) and mutual supporting in improvement activities, e.g. quality, production capacity, through the specific activities: education and training programs, evaluations, audits (51.8%). Some practices were also carried out less frequently. Every fifth company (18%) declared that it openly shared information about costs with the supplier. In turn, 36.4% of the surveyed organizations confirmed that the cooperation between the company's employees and the supplier's employees was very close (e.g. a product development team was created, consisting of the company's and the supplier's employees), and 41% that the cooperation with the supplier involved various management levels (e.g. strategic and operational).
Communication	Communication with the involved supplier was intensive (94.4%) and frequent (95.6%) in most cases. Moreover, it took place in a friendly atmosphere (98%), as well as using traditional methods, such as telephone or face-to-face meetings (97.6%). According to 67.2% of respondents, cooperation with the supplier involved employees from various departments of the company and employees from various departments of the supplier. Simultaneously, every second surveyed enterprise declared the use of advanced information and communication tools during SIPD (50.2%).

Source: own study **(pub.6, chapter 3)**.

Additional observations regarding the involvement of suppliers in product development, formulated in relation to the research results of other authors, include the following:

- The vast majority of companies implement a mature SIPD approach by deciding to involve suppliers early in product development, i.e. already during the generation and selection of ideas.
- The activities of enterprises operating on the Polish market fit into the integrated ESI definition, which includes coordinating product design, process design and supply chain design (Petersen, Handfield i Ragatz, 2005).
- In addition to suppliers, companies also willingly involve other stakeholders in development work, including customers and research institutions, giving these stakeholders less or similar responsibility for product development projects than suppliers. This indicates that enterprises implement the open innovation model (Chesbrough, 2003, s. 43; Enkel, Gassmann i Chesbrough, 2009).

- According to the results of previous research, companies are most willing to involve suppliers of complex and innovative goods into development work (especially in the first stages of NPD) (Birou, Fawcett, 1994; Liker, Kamath, and Wasti, 1998; Handfield et al., 1999; Mikkola and Skjoett-Larsen, 2003). Supply chains for these types of goods are managed in an agile approach (Witkowski, 2010, s. 59; Arnold, Chapman, Clive, 2012, p. 57). However, the obtained survey results indicate that ESI also occurs in the case of cooperation with partners providing goods with a lower degree of complexity. Moreover, the surveyed companies implemented SIPD not only in the case of agile supply chain management, but also when implementing a lean strategy. This is also confirmed by the characteristics most often declared by respondents describing products developed in cooperation with suppliers, such as: relatively high uncertainty of demand (determining production "to order"), medium degree of: complexity, diversity and newness of products, as well as medium or short total delivery time.
- According to the authors of the supplier-buyer relationship portfolio models (Kraljic, 1983; Olsen, Ellram, 1997; Bensaou, 1999), as well as the authors of other studies on SIPD (Kamath, Liker, 1994; Nellore, Söderquist, 2000), cooperation in the area of product development mainly concerns strategic suppliers, while giving them key responsibility for developing the technical specifications of the supplied goods. However, the results of the quantitative study show that SIPD also applies to a situation in which "the difficulty of managing the purchase process" and "the importance of the purchase" are at medium level. This partially confirms the observation from several years ago that ESI may take into account the involvement of suppliers of "leverage" goods (Saunders et al., 2015).
- The results I obtained confirm that the decision to select a supplier, based on the analysis of various criteria, plays an important role in SIPD (Handfield i inni, 1999; Ragatz, Handfield, Petersen, 2002; Spina, Verganti, Zotteri, 2002; Wagner, Hoegl, 2006; Schoenherr i Wagner, 2016). Enterprises operating on the Polish market declared that they carried out a detailed or very detailed assessment of the supplier before involving in product development process. This proves the critical importance of R&D work for supply chain management.
- Enterprises, despite the modern internationalization of supply chains, are most willing to include first-tier suppliers located in our country.
- In our country, cooperation with suppliers in the product development process is characterized by both trust and commitment. The companies' trust results from the belief in both the partner's friendliness and honesty, as well as technical/technological capabilities, and, consequently, in the certainty that the supplier will fulfill its obligations and respond with understanding to the problems and crisis situations occurring at the buyer.

- The commitment of the surveyed companies is associated with a highly positive attitude of buyers towards cooperation with the supplier, as well as demonstrating responsible actions by top management, including investing company resources (both tangible and intangible) in the business relationship. Decisions related to this result largely from the assessment of supplier-client relationship in terms of costs and benefits.
- The obtained results confirm that developing products with suppliers increases interdependence between enterprises (LaBahn and Krapfel, 2000), and that dependence on the supplier encourages investments, consequently increasing company commitment, which then increases the dependence of clients (Carr et al., 2008; Wagner, 2012). Enterprises operating on the Polish market recognize this aspect and declare that they have limited possibilities of achieving their goals without the supplier's involvement in the NPD process. Dependence on the supplier increases with the volume of goods purchased. As a consequence, any success or problem of the supplier may affect the continuity of the client's processes. At the same time, a potential change of supplier is very difficult for companies, as it is often associated with unacceptable costs.
- SIPD przedsiębiorstw w naszym kraju charakteryzuje kształtowanie relacji partnerskich na podstawie wspólnie wytyczonych (również długoterminowych) celów oraz sprawiedliwego podziału korzyści i ryzyka. Niemal w co drugim przypadku oznacza to także współdzielenie różnorodnych zasobów, w tym dzielenie się wiedzą i informacjami. Kluczowe znaczenie dla skuteczności realizowania takich praktyk mają komunikacja wewnątrz przedsiębiorstwa, integracja funkcjonalna oraz integracja działów współpracujących ze sobą firm
- SIPD of enterprises in our country is characterized by the development of partnership relationship on the basis of jointly set (also long-term) goals and a fair division of benefits and risks. In almost every second case, it also means sharing various resources, including sharing knowledge and information. Internal communications, functional integration and integration of departments of cooperating companies are of key importance for the effectiveness of such practices (Wynstra and Ten Pierick, 2000; Le Dain, Calvi and Cheriti, 2010; Lee and Wang, 2012; Chien and Chen, 2010; Mikkelsen and Johnsen, 2019). This is also confirmed by the results of the survey conducted.
- In our country, communication during SIPD is intensive, frequent and two-way. It is carried out largely using traditional methods. This may have a positive impact on the creation of relational capital in the supply chain (Birou, Fawcett, 1994; Hartley, Zirger, Kamath, 1997; Culley, Boston, McMahon, 1999).
- As shown by a systematic review of the literature on the subject, advanced information and communication tools are not widely used during SIPD projects. This is most likely why only a small number of authors paid attention to them (Chuang i O'Grady, 2001; Huang i Mak,

2003; Tang, Eversheim i Schuh, 2004; Humphreys, Huang i Cadden, 2005). Despite the rapid development of ICT technology, there have been no new publications on this subject in recent years. It is worth noting, however, that in Poland, every second cooperation surveyed is supported by advanced information and communication tools. Increasingly easier access to this type of solutions may be important for achieving research and development goals, especially when partners are located at a great distance or conduct many product development projects simultaneously.

An attempt to fill research gap number 2 – the impact of supplier involvement in product development on supply chain risk, supply chain resilience and supplier relationship resilience

The first theoretical model allowed for testing the impact of supplier involvement in product development on supply chain risk and supply chain resilience (Figure 4). It was created based on four main hypotheses. I constructed them myself, in relation to the results of previous research presented in the literature on the topic of supplier involvement in product development, supply chain risk and supply chain resilience[14]:

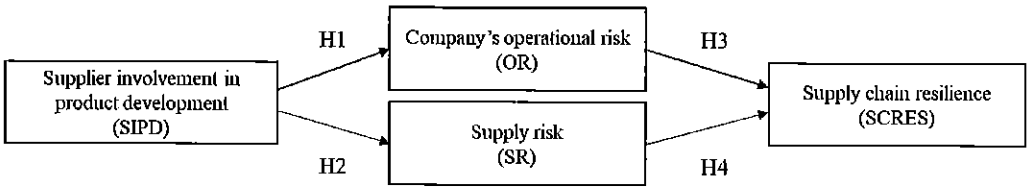
H1. Supplier involvement in product development reduces a company's operational risk.

H2. Supplier involvement in product development reduces supply risk.

H3. A company's reduced operational risk positively impacts supply chain resilience.

H4. Reduced supply risk positively impacts supply chain resilience.

Figure 4. Theoretical model I



Source: own study **(pub.5)**.

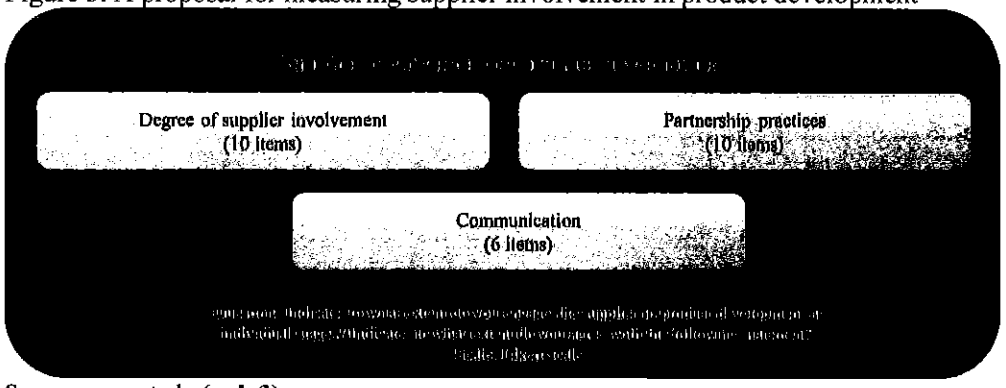
A method for measuring supplier involvement in product development

The method I developed for measuring supplier involvement in product development was the result of extensive research on SIPD (**pub.3, pub.5**). It included three proposed constructs: *degree of supplier involvement in product development* (DSI), *partnership practices during supplier involvement in product development* (PSI), *communication during supplier involvement in product*

[14] Detailed considerations leading to the development of each hypothesis can be found in publication 5.

development (CSI) (Figure 5). In total, they consisted of 26 measurable variables. Each variable was created using the literature on the subject [15].

Figure 5. A proposal for measuring supplier involvement in product development



Source: own study **(pub.3)**.

The proposed variables constitute a comprehensive list of good practices for SIPD that can be applied by supply chain managers. The degree of supplier involvement in product development refers to the subsequent stages of the product development process in which suppliers may become involved. The two other proposed constructs are a source of information on how to implement cooperation, including communication with suppliers, in the product development process.

As in the quantitative study I focused on a **single relationship**: a key supplier involved in the development process - a customer, the observable variables were slightly modified in order to adapt them to the research perspective used.

A method of measuring supply chain risk

I defined the supply chain risk as supply risk and company's operational risk, referring to its basic classification (Manuj and Mentzer, 2008). I expressed company's operational risk (OR) and supply risk (SR) with my own proposal of the constructs, observable variables and measurement scale, based on knowledge of the literature on the subject and the research carried out so far. (Johnson, 2001; Pfohl, Gallus, and Thomas, 2011, Wieteska 2011).

The proposal of the OR construct took into account the definition of operational risk and information security risk, i.e. the risk of personnel failures, risk of inadequate or failed internal processes (e.g. implementing incorrect procedures/instructions), the risk of machine breakdowns, risk related to the product (commodity) security (e.g. theft, burglary, damage) and the risk related to the information security (e.g. loss of confidentiality, integrity, availability). The proposal of the SR construct took into account: the key risk in supplier relationship, i.e. risk of untimely deliveries, risk of poor technical quality of deliveries and risk of quantitative non-compliance in deliveries. **(pub.7)**.

A method of measuring supply chain resilience

The supply chain resilience measurement (SCRES) was adapted from another author's study (Ponomarov 2012, p. 76). At the time of development of the "CATI 2" questionnaire, it was a

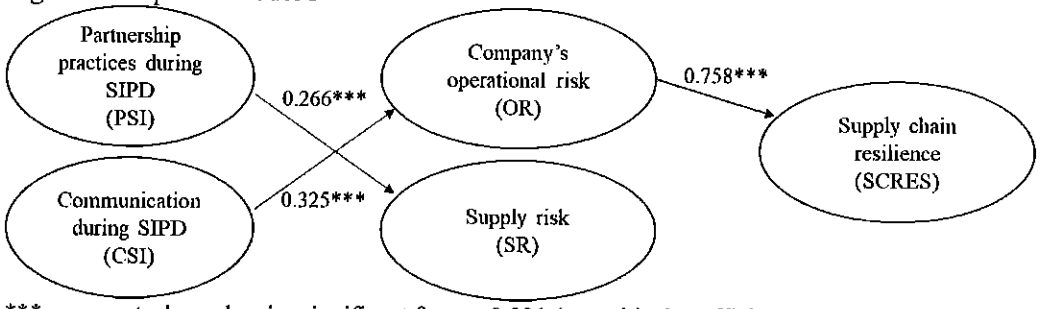
[15] The proposed constructs, together with the variables and sources of literature on the subject that were used to develop them, are described in detail in publication 3.

construct that was used by this author in research on enterprise innovation and created based on a detailed analysis of the literature on the subject. I also decided to use it because it expressed SCRES in accordance with the definition of a supply chain resilience I selected for the purposes of my research **(pub.2)**.

Verification of the theoretical model I

In order to confirm the reliability and validity of the developed constructs, I used the Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA) [16]. I used structural equation modeling to evaluate the theoretical model, which ultimately determined the construction of empirical model I for the impact of SIPD on supply chain risk and supply chain resilience (Figure 6).

Figure 6. Empirical model I



*** represents dependencies significant for $p < 0{,}001$ (p – critical coefficient)
Source: own study **(pub.5)**.

As a result, the hypotheses were verified as follows:

H1 – the impact of communication during supplier involvement in product development on the reduction of company's operational risk was confirmed.

H2 – the impact of communication during supplier involvement in product development on the reduction of company's operational risk was confirmed.

H3 – the positive impact of reduced company's operational risk on the supply chain resilience was confirmed.

H4 – the impact of reduced supply risk on the supply chain resilience has not been confirmed.

A construct that was created but excluded from empirical model I is the degree of supplier involvement in product development.

Verification of the proposed constructs, verification of model I and verification of hypotheses (H1-H4) allowed for the recognition that SIPD reduces supply chain risk, indirectly strengthening the supply chain resilience:

- Properly shaped SIPD (striving for long-term relationship involving employees at various levels, sharing technical/technological knowledge, sharing information on costs, mutual support in improving quality and production capacity, building cross-functional teams consisting of employees from both sides of the relationship) reduces supply risk, including

[16] Detailed results in this regard can be found in publication 5.

risk of untimely deliveries, risk of poor technical quality of deliveries and risk of quantitative non-compliance in deliveries.

- In order to reduce company's operational risk (especially the risk of personnel failures and risk of inadequate or failed value added processes), an improvement of communication in the supplier-buyer relationship during the product development process becomes particularly important. In turn, reduced operational risk is an opportunity to increase the supply chain resilience[17].

At this point, I would like to add that the article published in *Operations and Supply Chain Management-An International Journal* (pub.5), in which I presented model I, is of interest to scientists at the international level, as indicated by the citations: 25 according to Publish and Perish, (excluding self-citations).

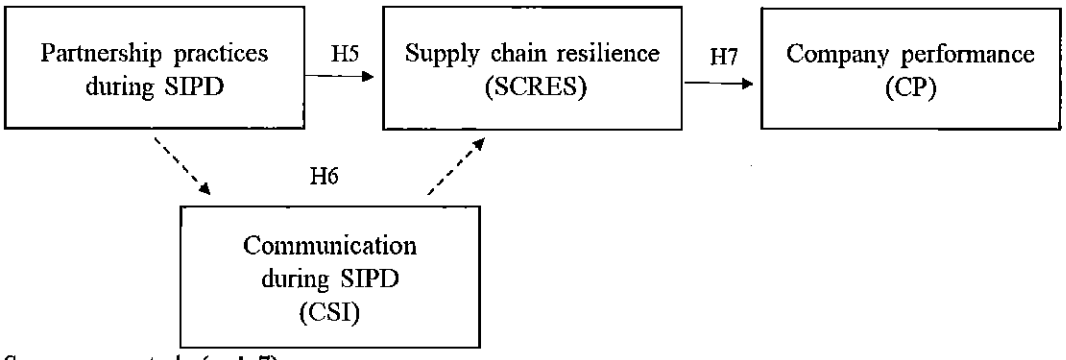
The second theoretical model allowed for deepening knowledge about the importance of communication during SIPD for building supply chain resilience and improving company performance (Figure 7). It was created based on the three main (next in the publication series) hypotheses. I constructed them myself, in relation to the results of previous research presented in the literature on the supplier involvement in product development, supply chain resilience and company performance in SIPD[18] **(pub.4, pub.7)**:

H5. There is a statistically significant direct effect of partnership practices during SIPD on SCRES.

H6. There is a statistically significant indirect effect of partnership practices during SIPD on SCRES through communication (CSI) as a mediating variable.

H7. There is statistically significant direct effect of SCRES on company performance.

Figure 7. Theoretical model II



Source: own study **(pub.7)**.

[17] All obtained results were subjected to a multi-threaded discussion against the background of the literature on the subject, which can be found in publication 5.

[18] Detailed considerations leading to the development of each hypothesis can be found in publication 7.

A method of measuring the company performance

The company performance (CP) were expressed by the author's proposed construct containing four observable variables (net profit, sales growth, lead time for fulfilling customers' orders and customer satisfaction) and a measurement scale. To develop the CP measurement method, I used the results of the analysis of the literature on the effects obtained in SIPD **(pub.6, pub.7)**.

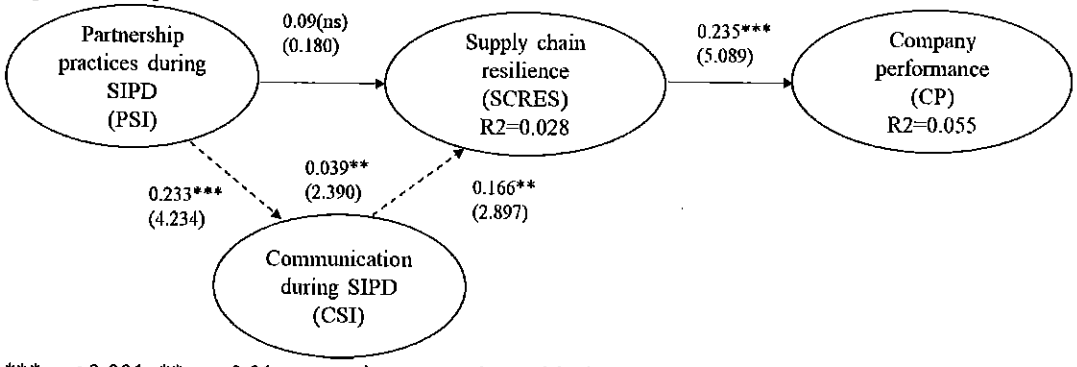
Other measurement methods used in the study

The methods for measuring partnership practices during SIPD (PSI)[19], communication during SIPD (CSI) and supply chain resilience (SCRES) were the same ones that I used to develop model I **(pub.5)**.

Verification of the theoretical model II

In order to confirm the reliability and validity of the developed construct, the Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA) were used[20]. The structural equation modeling was also used to evaluate the theoretical model, which ultimately determined the construction of empirical model II for the impact of SIPD on supply chain resilience and company performance (Figure 8).

Figure 8. Empirical model II



*** p < 0,001; ** p < 0,01; ns = unimportant; (p – critical coefficient, R – coefficient of determination)
Source: own study **(pub.8)**.

As a result, the hypotheses were verified as follows:

H5 – the direct impact of partnership practices during SIPD on supply chain resilience has not been confirmed.

H6 – the indirect influence of partnership practices during SIPD on SCRES through communication being a mediating variable was confirmed.

H7 – the direct impact of SCRES on the company performance was confirmed.

A construct that was created but excluded from empirical model II is the degree of supplier involvement in product development.

Verification of the proposed constructs, model II and hypotheses (H5-H7) allowed for the conclusion that, in the face of the challenge of building supply chain resilience, manufacturing

[19] In publication 7 I used the construct name: supplier involvement in product development (SIPD).
[20] Detailed results in this regard can be found in publication 7.

companies should improve cooperation in SIPD through the implementation of proper practices, whereas:

- The impact of partnership practices during SIPD on SCRES is only possible by ensuring frequent, intensive (large amount of information and knowledge exchanged) and, especially, direct communication conducted in a friendly atmosphere.
- The strengthen supply chain resilience to disruptions as a result of SIPD has a positive impact on the company performance, i.e. net profit, sales growth, lead time for fulfilling customers' orders and customer satisfaction[21].

The third theoretical model allowed for testing the impact of supplier involvement in product development on the supplier relationship resilience (expressed as flexibility and redundancy) and on the company business performance (Figure 9). It was created based on the five main (next in the publication series) hypotheses. I constructed them myself, in relation to the results of previous research presented in the literature on the supplier involvement in product development, flexibility and redundancy in relationship with suppliers and company performance in SIPD **(pub.4, pub.8)**[22]:

H8. Supplier involvement in product development, understood as the degree of supplier involvement in product development, partnership practices and communication with the involved supplier increases the flexibility of the relationship with the involved supplier.

H9. Supplier involvement in product development, understood as the degree of supplier involvement in product development, partnership practices and communication with the involved supplier decreases redundancy in the relationship with the involved supplier.

H10. Supplier involvement in product development, understood as the degree of supplier involvement in product development, partnership practices as well as communication with involved supplier, positively impacts company performance.

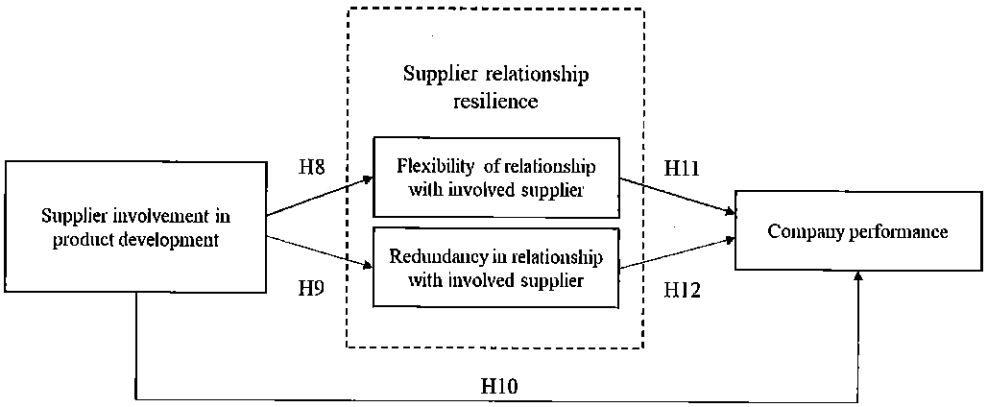
H11. Increased flexibility of relationship with involved supplier positively impacts company performance.

H12. Decreased redundancy in relationship with involved supplier positively impacts company performance.

[21] All obtained results were subjected to a multi-threaded discussion against the background of the literature on the subject, which can be found in publication 7.

[22] Detailed considerations leading to the derivation of each hypothesis can be found in the publication 8.

Figure 9. Theoretical model III

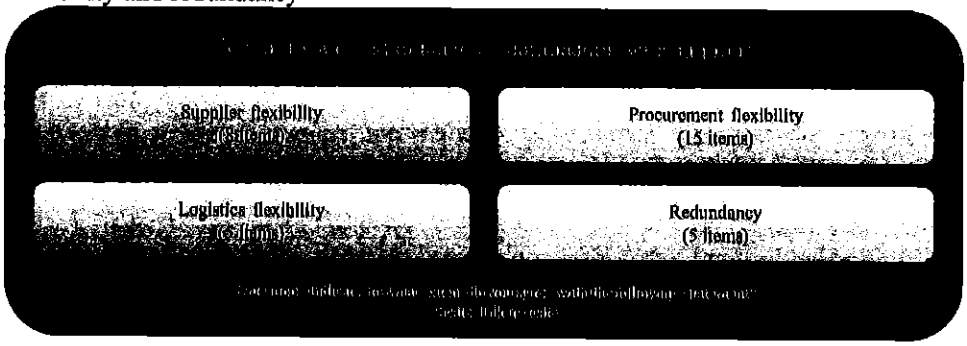


Source: own study **(pub.8)**.

A method for measuring supplier relationship resilience

The method I developed for measuring the supplier relationship resilience was the result of research on SCRES. It included four proposed constructs: *supplier flexibility* (SF), *procurement flexibility* (PF), *logistics flexibility* (LF) and *redundancy* (RED) (Figure 10). In total, they consisted of 33 measurable variables. Each variable was created using the literature on the subject[23].

Figure 10. A proposal for measuring the supplier relationship resilience – the perspective of flexibility and redundancy



Source: own study **(pub.4)**.

The variables represent a comprehensive list of best practices that can be applied by supply chain managers. Purchasing flexibility is associated, among other things, with the ability to shift orders between suppliers. If these costs are too high, flexibility in relationships with suppliers can be achieved by stimulating four dimensions of supplier flexibility (which are a result of the flexibility of their production systems), namely: volume flexibility, delivery (time) flexibility, mix flexibility, and new product flexibility. If the supply chain flexibility is insufficient to respond to present or future crises, it is suggested to implement adaptability strategies, understood as the introduction of permanent modifications aimed at adjusting to significant environmental changes (e.g., Chan et al., 2009; Engelhardt-Nowitzki, 2012; Kramarz & Kramarz, 2014). In the literature on the subject,

[23] The proposed constructs, along with the variables and sources of literature on the subject that were used to develop them, are described in detail in publication 4.

adaptive purchasing is treated as structural flexibility, which is expressed through redundancy practices, such as having backup suppliers or maintaining safety stock (Christopher & Holweg, 2011).

Because in the quantitative study I focused on a **single relationship**: a key supplier involved in the development process - a customer, the observable variables (especially in the case of "procurement flexibility") were slightly modified in order to adapt them to the research perspective used.

Other measurement methods used in the study

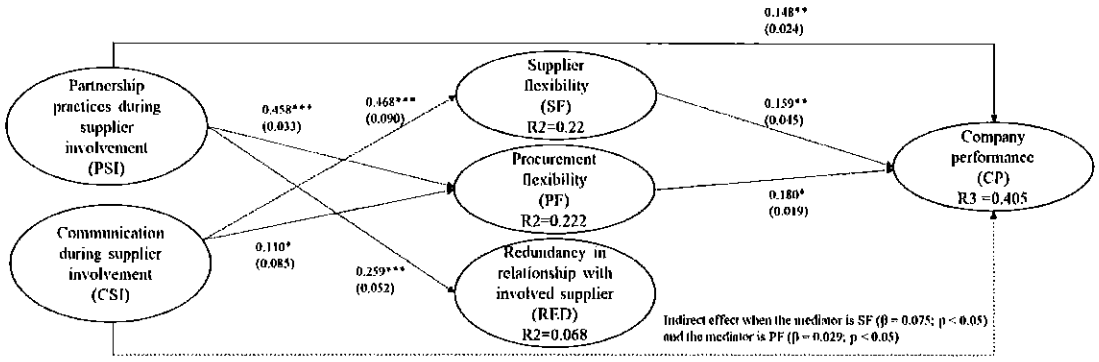
I expressed the supplier involvement in product development (SIPD) with three constructs adapted from the measurement method proposed for model I, i.e. the degree of supplier involvement in product development (DSI), partner practices during SIPD (PSI)[24] and communication during SIPD (CSI) (**pub.5**).

The method of measuring the company performance was the same one I used when developing model II (**pub.7**).

Verification of the theoretical model III

In order to confirm the reliability and validity of the developed constructs, I used the Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA)[25]. In order to confirm the reliability and validity of the developed constructs, I used the Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA). I used structural equation modeling to evaluate the theoretical model, which ultimately determined the construction of empirical model III for the impact of SIPD on the resilience of the relationship with the involved supplier and the company performance (Figure 11).

Figure 11. Empirical model III



*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$
Source: own study **(pub.8)**.

[24] In publication 8, I used the construct name: collaborative practices during supplier involvement (CPSI).
[25] Detailed results in this regard can be found in publication 8.

As a result, the hypotheses were verified as follows:

H8 – the impact of partnership practices during SIPD on increasing procurement flexibility, and the impact of communication during SIPD on increasing supplier flexibility and procurement flexibility were confirmed.

H9 – the impact of partnership practices during SIPD on decreasing redundancy in relationship with involved supplier.

H10 – the impact of partnership practices during SIPD on company performance was confirmed, and the indirect impact of communication during SIPD on the company performance was confirmed through supplier flexibility and procurement flexibility, which are mediating variables.

H11 – the impact of increased supplier flexibility and increased procurement flexibility on the company performance were confirmed.

H12 – the impact of reduced redundancy on the company performance has not been confirmed.

Opracowane konstrukty, które zostały wyłączone z empirycznego modelu III to stopień włączenia dostawcy w rozwój produktu i elastyczność logistyczna.

Verification of the proposed constructs, model III and hypotheses (H8-H12) allowed to recognize that SIPD affects the resilience of supplier-buyer relationship and the company performance. However, this impact is not unequivocal:

- Partnership practices during SIPD contribute to increasing procurement flexibility, and communication during SIPD enhances procurement flexibility and supplier flexibility, but partnership practices during SIPD lead also to the reduction in redundancy (especially in keeping safety stocks by supplier and/or buyer, or sending orders to the supplier in advance). This means that supply chain managers, especially in the face of modern global crises (which can weaken supplier bases), should reassess ensuring resilient relationships with suppliers involved in the product development process.
- A particular opportunity should be seen in improving supplier flexibility and procurement flexibility. Mainly, improving the flexibility of relationships with suppliers translates directly into improving the company performance[26].

An attempt to fill research gap number 3 – on the possibilities of shaping supply chains with reduced negative impact on the natural environment, in cooperation with suppliers in the product development process

The results of the quantitative study ("CATI 2") allowed to recognize that product development in cooperation with suppliers is focused, to a very large extent, on finding opportunities to reduce the negative impact of the product and supply chain processes on the natural environment. The vast

[26] All obtained results were subjected to a multi-threaded discussion against the background of the literature on the subject, which can be found in publication 8.

majority of surveyed companies stated that development work carried out in cooperation with the supplier took environmental issues into account[27]. Such a conscious approach of companies is beneficial in the light of global striving for green transformation, minimizing the negative impacts of value chains and greening production and consumption. (**pub. 6, chapter 3**):

- 89.4% of SIPD projects took into account the entire product life cycle.
- 90.2% of respondents declared that the discussed SIPD project implemented the principle of minimizing the negative impact of value-adding processes such as acquisition of raw materials and procurement, production, and distribution on the natural environment.
- 92% of companies agreed with the statement that the project took into account the principle of minimizing the negative impact on the natural environment during its use.
- 86.4% of enterprises were guided by the principle of reusing waste generated in the supply chain.
- 91,2% of the surveyed projects were aimed at increasing the degree of modularity of the product architecture.

In the study, I also collected companies' opinions **on the impact of including suppliers in product development on sustainability risk.** Most respondents indicated that SIPD determines the reduction of financial risk (63.6%), less than half of the companies notice the impact of SIPD on the reduction of environmental risk (45.6%), while every fourth respondent - on social risk (17.2%).

Even though companies declare to take into account the design for the environment approach and the circular economy principles, the analyzed literature on the subject lacks a description of best practices in reducing the negative impact of supply chain processes on the natural environment in product development projects in which suppliers are involved. Therefore, I decided to develop case studies in this area („IDI 9-14", „case studies 2-7").

Each of the six "eco-projects" described in the monograph concerns cooperation with suppliers in the product development process and a selected other process improved in environmental terms. I referred the processes to the following stages of the closed product life cycle, which are: supply of raw materials, design, production, distribution, use and disposal (Ulrich and Eppinger, 2011, p. 238-241; Greszta and Osowiecka, 2016, p. 35-42). Subsequent case studies also present the use of a different "*Design for..*" approaches, within *Design for Environment* (Fiksel, 2009), which, when implemented in the product development process, affect not only the developed products, but also the value-adding processes, i.e.

- Case study 1 – *Design for Sustainability*. Main goal: reducing the negative impact on the natural environment at the stage of purchasing raw materials for production.

[27] In the study, I asked the respondent to refer to one of the implemented SIPD projects and cooperation with a key supplier in this project.

- Case study 2 – *Design for Detoxification*. Main goal: reducing the negative impact on the natural environment at the product design stage.
- Case study 3 – *Design for Environment*. Main goal: reducing the negative impact on the natural environment at the production stage.
- Case study 4 – *Design for Release Reduction*. Main goal: reducing the negative impact on the natural environment at stage product distribution.
- Case study 5 – *Design for Dematerialization and Design for Servicization*. Main goal: reducing the negative impact on the natural environment at the stage of product use.
- Case study 6 – *Design for Disassembly*. Main goal: reducing the negative impact on the natural environment at the stage of product disposal.

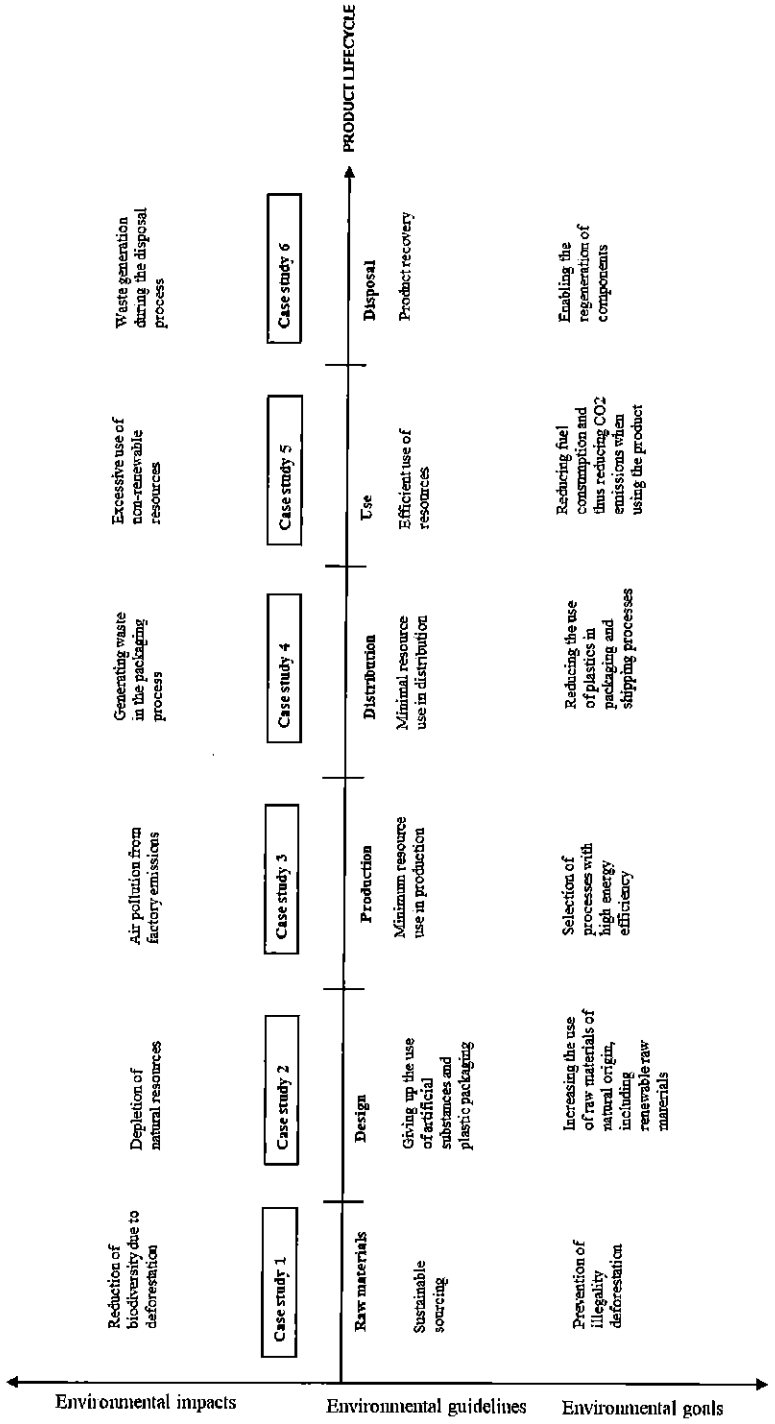
Tabel 8. Basic information about manufacturing companies in the study.

Case study	1	2	3	4	5	6
Company size	Medium	Small	Large	Small	Small	Small
Origin of capital	Domestic	Domestic	Foreign	Domestic	Domestic	Domestic
PKD	Section 10. Production of food products	Division 23. Production of products from other non-metallic mineral raw materials	Division 27. Production of electrical equipment	Chapter 16. Manufacture of products of wood and cork, except furniture	Division 29. Manufacture of motor vehicles, trailers and semi-trailers, except motorcycles	Division 26. Production of computers, electronic and optical products
Respondent's position	Laboratory manager and quality management representative	PR&Marketing Manager	Commercial director	Co-owner of the company	Company owner	President of the Management Board

Source: own study (pub.6, chapter 4).

Case studies provide detailed illustrations of how companies work in partnership to meet environmental guidelines and goals and implement changes to products and processes (Figure 12).

Figure 12. Impacts, guidelines and environmental objectives of studied SIPD projects.



Source: own study (pub.6, chapter 4).

Each described cooperation is carried out under specific conditions and differs in terms of the length and characteristics of the relationship (commitment, trust, dependencies) in the supply chain, the type of goods purchased and the type of product innovation introduced (Table 9).[28]

[28] More information on the type of companies studied can be found in publication 6 (chapter 4).

Table 9. Features of relationship with supplier involved in the product development process.

Studium przypadku	1	2	3	4	5	6
Relationship lenght with involved supplier	24 months	37 months	A dozen years	A dozen years	A dozen years	A dozen years
The company's trust in the involved supplier (1 – very low, 5 – very high)	4	4	5	5	5	5
The degree of the company's dependence on the supplier (1 – very small, 5 – very large)	4	3	5	4	5	4
The degree of the company's involvement in the relationship (1 – very small, 5 – very large)	5	3	5	4	5	4
The size of changes introduced in the product (1 – gradual, small innovation, 5 – very large, radical innovation)	5	5	3	3	5	4
Market availability of the good purchased from the supplier (1 – very small, 5 – very large)	3	3	2	3	5	5
The impact of the purchased good on the value of the manufactured product (1 – very small, 5 – very large)	3	4	4	5	5	3
Degree of supplier's involvement in the project (1 – very small, 5 – very large)	3	4	4	4	5	4

Source: own study (pub.6, chapter 4).

As the presented case studies show, understanding the principles of pro-environmental cooperation with suppliers in the area of product development is closely related to recognizing the operating context of a given enterprise, i.e. its place in the value chain, the implemented strategy, the type of customer requirements and expectations, the stages of the product life cycle and legal regulations, as well as the market for purchased goods. Relationships with suppliers are only part of the product development chain. Regardless of the "*Design for..*" approach and the improved process, cooperation is also conditioned by many other factors that concern:

- Studied enterprises (degree of internal integration, presence of cross-functional NPD teams, early inclusion of purchases in the product development process, implementation of detailed supplier assessment).
- Suppliers of the surveyed enterprises (technological capabilities, innovativeness, possibility of early involvement in the client's product development process).

- Supplier-company relationship (mutual trust and commitment, interdependencies, skills and social competences of employees of both companies, two-way and active communication, degree of external integration).

However, the critical success factor of SIPD eco-projects seems to be, apart from issues such as idea accuracy or the detailed technical and business assessment of the concept - the top management's awareness of contemporary environmental problems and the focus of supply chain participants on running a responsible business.

Recommendations for manufacturing companies

Against the background of the results and conclusions from the conducted research, I formulated a number of recommendations for manufacturing companies that strive to achieve better and better results of cooperation in the product development chain in the face of such contemporary challenges as the need to build the resilience of supply chains and reduce their negative impact on the natural environment. The most important recommendations are:

- The product development process is a significant source of disruptions that spread to other processes in supply chains. An opportunity to reduce their risk and increase the resilience of supply chains (especially in the sense of mitigating the effects of disruptions) is to involve suppliers in this process.
- Conscious efforts should be made to integrate product design, process design and supply chain design activities, while taking into account opportunities to build resilience to disruptions.
- In the product development process, well-thought-out purchasing decisions should be made, as they have a key impact on the resilience of the supply chain, especially the supplier relationship resilience.
- When deciding to work with suppliers in the product development process, you should consider implementing an early onboarding strategy for ESI suppliers, which provides the greatest benefits.
- Involving suppliers in the product development process should not be limited only to suppliers of strategic goods.
- In order to increase the maturity of cooperation with various supplier segments in the product development process, it is worth referring to the supplier-buyer relationship portfolio models developed in this area.
- The potential of involving suppliers in product development results from, among others, from: a long-term perspective of cooperation, mutual trust, mutual commitment (employees from different management levels, cross-functional teams), sharing technical/technological

knowledge and information on costs, or mutual support in improving product quality and technological and production capabilities (e.g. supplier development programs, audits).

- Implementation of the strategy of supplier involvement in product development, while implementing best practices in this area, is an opportunity to reduce risk and strengthen the resilience of supply chains of manufacturing enterprises. The developed list of good practices for supplier involvement in product development (Figure 5, pub. 3) can also be implemented in cooperation with other stakeholders in the product development chain.
- In the face of environmental variability and new global threats, there is a need to increase the use of advanced Information and Communication Tools (ICT) in cooperation with suppliers when developing product innovations.
- Despite ongoing digitalization, direct communication and the development of social competences of participating employees are still key to the success of SIPD projects.
- Communication during SIPD should be characterized by a high frequency of exchanged messages and intensity, which means readiness to share a sufficiently large amount of information and knowledge.
- Communication during SIPD should also be improved because it reduces operational risk in the enterprise and improves the flexibility of relationships with suppliers, which translates into greater supply chain resilience and better business results.
- Although trust and commitment are the dominant features of a mature SIPD, companies should not forget about the strong dependencies that appear in relationships with suppliers involved in the development process. These dependencies are a source of increased risk, the effects of which may spread in the form of a domino effect in supply chains. There is therefore a need for conscious integration of SIPD financial objectives with risk management and business continuity objectives in the supply chain. Maintaining inventory buffers, abandoning the single source of supply strategy, or maintaining cooperation with emergency suppliers means an increase in the company's operating costs, but on the other hand, redundancy is one of the key attributes of supply chains resistant to disruptions.
- A special opportunity should be seen in improving supplier flexibility and improving procurement flexibility. This type of improvement in the flexibility of supplier relationships translates directly into better company performance.
- In the face of growing problems of environmental pollution and accelerating climate change, cooperation with suppliers in the product development process should be treated as an opportunity to effectively and efficiently reduce the negative impact of products and supply chain processes on the natural environment.

- Cross-functional SIPD teams consisting of supplier and buyer employees should include specialists in supply chain management, sustainable development, circular economy, and financial and non-financial risk management.
- SIPD eco-projects can be successfully implemented regardless of the size of the enterprise, the origin of capital or PKD.
- Against the background of contemporary trends affecting supply chain management, it becomes appropriate to develop products using "*Design for..*" approaches, in particular: Design for Environment, Design for Sustainable Development and Design for Circular Economy.
- Due to the relationship between eco-design and closing the product life cycle, the possibility of implementing circular economy principles in product design should be taken into account already in the initial stages of cooperation with suppliers in the product development process.

4.4. The contribution of the publication series to the development of management and quality sciences and its implications for business practice.

The publication series of entitled " Supplier involvement in product development as an opportunity to build supply chain resilience and reduce the negative impact of supply chains on the natural environment" has become the basis for the integration and systematization of knowledge for three subdisciplines, i.e. logistics management, strategic management and innovation management. A systematic literature review, which I conducted, has shown that the issues of cooperation with suppliers in the product development process, supply chain resilience, supplier relationship resilience in conditions of increasing environmental turbulence, as well as reducing the negative impact of products and value-adding processes on the natural environment, require qualitative and quantitative research. Therefore, based on the identified research gaps, I related the scientific achievements and research practices of strategic cooperation with suppliers in the area of product development to contemporary challenges of managing supply chains by manufacturing enterprises. The series is an attempt to integrate knowledge and research procedures regarding the supplier involvement in product development, building the resilience of B2B relationships in the light of flexibility and redundancy, and design for environment, with knowledge and research experience in the field of supply chain management in a process approach.

The most important **contribution of the publication series to the theory of management and quality sciences** are the following achievements:

- Providing a new approach to research, definition and new knowledge on the occurrence of the domino effect in supply chains, i.e. in relation to the epicenters of disruptions, directions of spread of negative effects in the process approach and sources of risk and uncertainty.

Determination of the role of the product development process in disruptions occurring in supply chains (pub.1).

- Providing new knowledge in the field of linking the product development process and the purchasing and supplier relationship management process with building resilient supply chains (pub.2).
- Providing a new term *supplier relationship resilience* and new knowledge about the resilience of supplier relationships (pub.2, pub.4, pub.8).
- Identifying and conceptualizing four constructs to measure the supplier relationship resilience, i.e. supplier flexibility, procurement flexibility, logistics flexibility, redundancy in the relationship with supplier (pub.4, pub.8).
- Development of the results of a systematic review of the literature from the last 30 years on SIPD research in terms of seven thematic areas, as well as identifying and filling key research gaps identified in this review (pub. 5, pub.6, pub.7, pub. 8).
- A model approach to the conditions for supplier involvement in product development (Figure 3), which is a source of information on how to shape cooperation with suppliers in the area of product development in order to achieve the best possible results (pub.6).
- Providing new knowledge regarding the implementation of strategy of supplier involvement in product development by manufacturing companies operating in our country (pub.6).
- Identify and conceptualize the following three constructs to measure supplier involvement in product development: degree of supplier involvement in product development, partnership practices during SIPD, and communication during SIPD (pub.3, pub.6).
- Development and verification of measurement methods for: supplier involvement in product development, supply risk, operational risk, resilience of relationship with a supplier involved in the product development process, company performance (pub.3, pub.4, pub.5, pub.7, pub.8).
- Constructing a structural equation model and determining the impact of SIPD on supply chain risk and supply chain resilience (pub.5).
- Constructing a structural equation model II and determining the impact of SIPD, including communication, on the supply chain resilience and company performance (pub.7).
- Constructing a structural equation model III and determining the impact of SIPD on the resilience of the relationship with the involved supplier and the company performance (pub.8).
- A contribution to the limited literature on Design for the Environment (DfE) and the Product Development Chain (*Product Development Chain*) (pub.2, pub.6)
- Describing examples of best practices regarding the possibility of shaping supply chains with reduced negative impact on the natural environment, in cooperation with suppliers in the

product development process, using Design for Environment approaches and in relation to each stage of the closed product life cycle, in line with the circular economy (pub.6).

- Providing a number of recommendations under SIPD for manufacturing enterprises, aimed at building supply chain resilience and reducing the negative impact of supply chains on the natural environment (pub.5, pub.6, pub.7, pub.8 - a list of the most important recommendations is presented at the end of point 4.3.).
- Introduction of the term *Design for Supply Chain RESilience* (DfSCRES) into the literature (pub. 6). DfSCRES integrates product design and the design of the product's supply chain with the implementation of resilient solutions for: 1. The product being developed (e.g. modularity of the architecture) 2. The product development process (e.g. involving suppliers in product development, ensuring appropriate communication in the product development chain, integration internal and external) 3. Structure and resources of the supply chain of the developed product (resilient capabilities and attributes - e.g. flexibility and redundancy).

The results of research conducted as part of the publication series have the following practical implications:

- Increasing the awareness of managers managing manufacturing companies regarding the importance of the product development process and the purchasing and supplier relationship management process for building the supply chain resilience (pub.1, pub.2, pub.5).
- Providing managers with comprehensive knowledge about the conditions (motivators, activating factors and barriers) for cooperation with suppliers in the area of product development (pub.6).
- Confirmation of the impact of SIPD on supply chain risk, supply chain resilience, supplier relationship resilience and company performance (pub.5, pub.7, pub.8).
- Instructing managers on how to cooperate with suppliers in the product development process to strengthen the resilience of supply chains and reduce their negative impact on the natural environment (pub.2, pub.5, pub.6, pub.7, pub.8).

I would like to emphasize the unique nature of the results I obtained, which I presented in relation to the three stages of the research, and which allowed me to fill the following research gaps I presented in 4.3.1., i.e. cognitive, empirical, applied and methodological.

There are several limitations to the research conducted. Firstly, in the quantitative study on the supplier involvement in product development ("CATI 2"), I applied the principle of representativeness when selecting the sample size. The too small number of companies operating in some of the surveyed PKD sections made it impossible to conduct a comparative analysis between them. Secondly, due to the very complex research issues I undertook and, on the other hand, the need to develop a questionnaire with an accessible number of questions and answers for the respondent,

some of the issues that interested me had to be deliberately omitted (e.g. assessment of the maturity of supply chain management according to the Poirier model, or assessment of risk management maturity in the examined supply chain). However, I am pursuing these issues in further research on design for supply chain resilience. Third, the factor that made it difficult to collect qualitative data to develop case studies on the role of SIPD in reducing the negative impact of supply chain processes on the natural environment was the COVID-19 pandemic. During the pandemic, reaching the experienced representatives of companies (with appropriate knowledge) and gaining their interest in the area of research on environmental aspects was not easy, because the priority of the companies was to concentrate all available resources on ensuring business continuity in supply chains and maintaining financial liquidity. Additionally, the development of products with suppliers is treated by companies as an important determinant of achieving competitive advantage. Therefore, reaching enterprises that agreed to share their experience and knowledge about the functioning of their own product development chain was difficult due to managers' fears of the risk of disclosing confidential information.

In future research, I suggest:

- Develop a definition and providing a detailed framework for a Design for Supply Chain Resilience (DfSCRES).
- Integrate the Design for Supply Chain Resilience approach with Design for Sustainability.
- Focus on identifying ICT tools for effective communication in global product development chains, as well as the possibility of building bonds between employees of product development chain participants, especially in international conditions characterized by cultural diversity.
- Explore the impact of specific Design for Environment approaches and circular economy on supply chain resilience.
- Investigate the impact of the use of Industry 5.0 technologies in the product development chain on the resilience of the supply chains to disruptions resulting from sustainability risks.
- Explore the impact of implementing ESG strategies on supply chain resilience.

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Szymczak, M. (2004), Logistyka w procesie internacjonalizacji przedsiębiorstw, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań.
Szymczak, M. (2017). Systemy performance measurement w budowaniu odpornych łańcuchów dostaw. Studia Ekonomiczne, (315), 109-119.
Tang, C. S., Zimmerman, J. D., & Nelson, J. I. (2009). Managing new product development and supply chain risks: The Boeing 787 case. In Supply Chain Forum: An International Journal, Vol. (2), 74-86).
Tang, D., Eversheim, W., & Schuh, G. (2004). A new generation of cooperative development paradigm in the tool and die making branch: strategy and technology. Robotics and Computer-Integrated Manufacturing, 20(4), 301-311.
Tłuczak, A., & Kauf, S. (2015). Badania rynkowe w zarządzaniu łańcuchem dostaw. Difin.
Tranfield D., Denyer D., Smart P., (2003), Towards a Methodology for Developing Evidence-informed Management Knowledge by Means of Systematic Review, British Journal of Management, 14(3), 207-222.
Tukamuhabwa, B. R., Stevenson, M., Busby, J., & Zorzini, M. (2015). Supply chain resilience: definition, review and theoretical foundations for further study. International Journal of Production Research, 53(18), 5592-5623.
Tundys, B. (2022). Zakłócenia incydentalne w łańcuchu dostaw—analiza ripple effect w świetle badań literaturowych. Gospodarka Materiałowa i Logistyka. 11, 16-28
Tundys B., Kędzia G, Wiśniewski T. & Zioło M., (2024), Sustainable Supply Chains 2.0: Towards Environmental, Social, and Economic Resilience, Palgrave Macmillan, London.
Ülkü, S., & Schmidt, G. M. (2011). Matching product architecture and supply chain configuration. Production and Operations Management, 20(1), 16-31.
Ulrich K.T. & Eppinger S.D. (2011), Product design and development, McGraw-Hill Education, New York.
Van Weele, A.J. (2014), Purchasing and supply chain management. Analysis, strategy, planning and practice, Cengagae Learning, Andover.
Venkatesh, V. G., Rathi, S., & Patwa, S. (2015). Analysis on supply chain risks in Indian apparel retail chains and proposal of risk prioritization model using Interpretive structural modeling. Journal of Retailing and Consumer Services, 26, 153-167.
Wagner, S. M. (2012). Tapping supplier innovation. Journal of Supply Chain Management, 48(2), 37-52.
Wagner, S. M., & Hoegl, M. (2006). Involving suppliers in product development: Insights from R&D directors and project managers. Industrial marketing management, 35(8), 936-943.
Wasilewski, W. (2019). Podejmowanie decyzji i zarządzanie ryzykiem w łańcuchach dostaw. Przedsiębiorczość i Zarządzanie, 20(5), 67-76.
Weber, A. N. (2021). Responding to supply chain disruptions caused by the COVID-19 pandemic. A Black Swan event for omnichannel retailers. Journal of Transport and Supply Chain Management, 15, 16.
Wieteska, G. (2011). Zarządzanie ryzykiem w łańcuchu dostaw na rynku B2B. Difin, Warszawa.
Wieteska, G. (2014). Supplier risk in building B2B relationships–portfolio models approach. International Journal of Supply Chain and Operations Resilience, 1(1), 104-120.
Wieteska, G. (2017). ESI in the supply chain of modular products. Problemy Transportu i Logistyki, 39(3), 129-140.
Witkowski, J. (2010), Zarządzanie łańcuchem dostaw: koncepcje, procedury, doświadczenia, Polskie Wydawnictwo Ekonomiczne, Warszawa.

Wynstra, F., & Ten Pierick, E. (2000). Managing supplier involvement in new product development: a portfolio approach. European Journal of Purchasing & Supply Management, 6(1), 49-57.
Yildiz Ozenc, S. C., Er, M., & Firat, S. U. (2023). Risks in Supply Chain 4.0: A Literature Review Study. In Global Joint Conference on Industrial Engineering and Its Application Areas (pp. 163-177). Springer, Cham, 163-177.
Zavala-Alcívar, A., Verdecho, M. J., & Alfaro-Saiz, J. J. (2020). A conceptual framework to manage resilience and increase sustainability in the supply chain. Sustainability, 12(16), 6300.
Zsidisin, G. A., & Smith, M. E. (2005). Managing supply risk with early supplier involvement: a case study and research propositions. Journal of supply chain management, 41(4), 44-57.

4.5. Presentation of other scientific and research achievements

4.5.1. Characteristics of scientific and research achievements until obtaining the degree of doctor of economic sciences in the field of management sciences

In the years 2000-2005, I studied full-time master's studies Environmental Protection at the University of Lodz. My master's thesis, written under the supervision of dr Adrianna Wojtal, titled: "Verification of the DALIS mathematical model version 1.0 for the Sulejów Reservoir" focused on the analysis of the dynamic system of a real natural phenomenon with revitalization potential for the second largest water reservoir in the Lodz Voivodeship. After graduating, I aimed to develop practical skills (e.g. I completed an internship at Optima S.A. and worked at the Agency for Restructuring and Modernization of Agriculture in Lodz), as well as to improve my knowledge of the external and internal environment of the organization (e.g. I graduated from one-year postgraduate studies in Occupational Health and Safety at the Lodz University of Technology, as well as courses in sustainable development and management systems).

My interest in business practice, acquired competences and knowledge of English and German allowed me to gain further professional experience, this time at Monnari Trade S.A., where I was employed in the Import Department and also joined Occupational Health and Safety team. My tasks in the field of purchasing and supply logistics included: developing and submitting inquiries and orders to suppliers, cooperation with foreign subcontractors and other company departments in the product development process and order fulfillment, participating in the periodic assessment of suppliers (manufacturers), building relationships with business partners from Europe and Asia, participating in the preparation and flow of financial and non-financial documentation in the supply chain, as well as planning and organizing international transport (sea, air and road transport) along with the implementation of inward processing procedures, in cooperation with forwarders, carriers and customs and tax offices.

In 2007, I was also employed as an assistant at the Department of Quality Management at the Faculty of Management of the University of Lodz, headed by dr hab. Maciej Urbaniak, prof. UŁ. Due to my research interests and practical knowledge in the field of purchasing, supply logistics and safety, I started research combining the issues of risk and cooperation in the supply chain. I also shared my knowledge and experience with students of the then newly created Logistics program. Additionally, I conducted training for students of the Faculty of Management in the field of occupational health and safety (in 2007, at the Lodz University of Technology, I received confirmation of my competences as an occupational health and safety lecturer).

I presented the first research results on risk in a manufacturing companies at two subsequent conferences gathering practitioners involved in ensuring industrial safety, organized by the Stowarzyszenie Bezpieczeństwa Technicznego. The results of these studies have also been published:

- Wieteska, G. (2008). Ryzyko w działalności przedsiębiorstw przemysłowych [w:] I. Sosnowski, M. Urbaniak (ed.), Bezpieczeństwa przemysłowe 2, Wydawnictwo Klub Paragraf 34, Warszawa, 81-87.
- Wieteska, G. (2009). Determinanty ciągłości działania w przedsiębiorstwie produkcyjnym, [w:] M. Urbaniak (ed.), Bezpieczeństwo Przemysłowe 3, Wydawnictwo Akcydens, Warszawa, 99-102.

The result of continuing research on the identification and impact of risk factors disrupting the flow of products and information in supply chains was the subsequent scientific articles I wrote. The first one was presented during the scientific conference "Logistics - a chance for the development of the city and the Piotrków region", organized by the Institute of Economics and Management of the Jan Kochanowski University of Humanities and Natural Sciences in Piotrków Trybunalski, in May 2008 in Sulejów:

- Wieteska, G. (2008). Wypadki i kradzieże samochodów ciężarowych jako czynniki zakłócające funkcjonowanie łańcuchów dostaw w Polsce, [in:] W. Starzyńska (ed.), Logistyka szansą rozwoju miasta i regionu na przykładzie ziemi piotrkowskiej, Uniwersytet Jana Kochanowskiego w Kielcach, 311-325.

The second one, I presented at an international scientific conference titled: "3rd International Scientific and Technical Conference: Logistics Systems. Theory and Practice", organized by the Warsaw University of Technology, 10.09.2008-12.09.2008 in Spała:

- Wieteska, G. (2009). Katastrofy naturalne jako czynnik zakłócający funkcjonowanie łańcuchów dostaw, Logistyka, (4), 1-12.

My subsequent publications on this subject also included:

- Wieteska, G. (2009). Bezpieczeństwo strumienia informacji, Logistyka, (4), 56-60.
- Wieteska, G. (2009). Czynniki ryzyka dla strumienia towaru w łańcuchu dostaw, Logistyka (3), 23-26.
- Wieteska, G. (2009). Bezpieczeństwo informacji jako istotny element zarządzania w łańcuchach dostaw. Gospodarka Materiałowa i Logistyka, (10), 4-11.
- Wieteska, G. (2010). Zagrożenia losowe i nielosowe dla ciągłości procesu transportu towarów. Logistyka, (1), 32-34.

I successfully defended my doctoral thesis entitled "Risk management in supplier-client relationships on the B2B market" on June 21, 2010. The supervisor of the work was dr hab. Maciej Urbaniak, prof. UŁ, and the reviewers: dr hab. Maciej Szymczak, prof. UEP and dr hab. Jarosław Sosnowski, prof. UŁ.

The doctoral thesis, supplemented with the most up-to-date literature on the subject and new practical aspects, due to its theoretical and application value, was published by Difin publishing

house as an author's monograph and has had 58 citations (excluding self-citations) according to Publish or Perish:

- Wieteska, G. (2011). Zarządzanie ryzykiem w łańcuchu dostaw na rynku B2B, Difin, Warszawa.

In 2012, I received an individual *award* of the third degree from the Rector of the University of Lodz for my book.

I also presented the results of the research I conducted before obtaining my doctoral degree in the following scientific publications:

- Wieteska, G. (2010). Potrzeba rozpoznawania zagrożeń w relacjach dostawca-odbiorca na rynku B2B. Gospodarka Materiałowa i Logistyka, (12), 7-13.
- Wieteska, G. (2011). Znaczenie działań ograniczających ryzyko w relacjach dostawca-odbiorca na rynku B2B. Gospodarka Materiałowa i Logistyka, (4), 11-18.
- Wieteska, G. (2011). Kryteria oceny źródeł zaopatrzenia bezpośrednich dostawców, jako element doskonalenia procesów logistycznych, Logistyka, (6), 15-18.
- Wieteska, G. (2011). Przeniesienie jako jedna z metod postępowania wobec ryzyka pojawiającego się w relacjach dostawca-odbiorca na rynku przedsiębiorstw, Logistyka, (2), 2-6.
- Wieteska, G. (2011). Rola ryzyka w budowaniu relacji z dostawcami, Acta Universitatis Lodziensis. Folia Oeconomica, numer 251, 235-261.
- Wieteska, G. (2012). Systemy zarządzania jakością i ich rola w zarządzaniu ryzykiem pojawiającym się w łańcuchu dostaw. Problemy Zarządzania, 2(37), 139-159.
- Wieteska, G. (2012). Otoczenie zewnętrzne jako źródło ryzyka dla uczestników łańcuchów dostaw. Marketing i Rynek, (1), 17-27.

4.5.2. Characteristics of scientific and research achievements after obtaining the degree of doctor of economic sciences in the field of management sciences

After obtaining a PhD in economics in the field of management sciences, I was employed as an assistant professor at the Department of Quality Management (after changing its name in 2012 - Department of Logistics), where I continued research related to the topics of my doctoral dissertation. I also became interested in new areas in which I was looking for research gaps.

In my scientific and research work, three additional, complementary research streams can be distinguished:

1. Improving supplier-client relationships on the B2B market.
2. Resilient and sustainable supply chains.
3. Supply chains in a circular economy.

4.5.2.1. The first research stream – Improving supplier-client relationships on the B2B market

In subsequent research, I focused on identifying strategies and practices for improving supplier relationships, and on recognizing the most common motivators for their implementation.[29]

Because the improvement of suppliers is carried out within the so-called supplier development programs, the results of a qualitative study on the role of supplier development in operational risk management, and then the results of a quantitative study on supplier development, I presented in the following publications, as well as at conferences in Poland and abroad:

- Wieteska, G. (2012). Operational risk management as the element of supplier development, ed. Claude M., Tawfik R, "L'entrepreneur Face aux Politiques Publiques Europeenees", Reseau PGV, UPNF Grenoble (at the conference: XVIII Conférence Scientifique Internationale du Ré seau PGV, Lizbona, Portugalia, 13.09.2012-14.09.2012).
- Wieteska, G. (2013). Rozwój dostawców w modelach portfolio relacji dostawca-nabywca, Logistyka, (5), 205-207 (at the conference: V International Scientific Logistics Conference WSL FORUM 2013, WSL Poznań, 10.05.2013).
- Wieteska, G. (2015). Rozwój dostawców na rynku B2B w Polsce w świetle wyników badań. Gospodarka Materiałowa i Logistyka, (1), 15-22.

At the same time, I became interested in the issue of improving relationships with suppliers in relation to supplier performance management and the so-called the supplier's life cycle, for which the decision to continue (or not) cooperation with the partner is crucial. Against this background, in the next publication I presented a model diagram of stages and activities for supplier performance management in accordance with the idea of continuous improvement:

- Wieteska, G. (2015). Mierzyć sprawność czy zarządzać sprawnością dostawców?. Marketing i Rynek, (2), 17-22.

In the research conducted, I also identified practices aimed at improving cooperation with suppliers that are implemented by manufacturing companies in our country:

- Wieteska, G. (2014). Improvement of suppliers in the B2B market. Logistyka, (3), 7228-7292 (w ramach konferencji: Polski Kongres Logistyczny LOGISTICS 2014 „Komunikacja w łańcuchach dostaw", Instytut Logistyki i Magazynowania, Poznań, 14.05.2014-16.05.2014).

[29] I conducted quantitative and qualitative research for this research stream as part of the grants received for young scientists: 1. Implementation of a team research topic titled "Supplier relationship management" (2012) and 2. Independent implementation of the research topic entitled "Directions of development of supplier relationship management strategies in the light of supplier-recipient relationship portfolio models" (2013) 3. Participation in statutory research of the Department of Logistics, Faculty of Management, University of Lodz: research task titled "The role of quality, environmental and safety management systems in improving processes in the supply chain" (2011-2014).

- Wieteska, G. (2014). Partnership initiatives in relations with suppliers and the reasons for their implementation-research results, Logistyka, (5), 2133-2139.

I identified that when deciding to improve cooperation with a supplier, especially in the face of the challenges of social and environmental responsibility, companies are guided by the risk and importance of suppliers (I used the Kraljic model for the study). Moreover, their activities are focused not only on knowledge transfer or investing in suppliers' infrastructure, but also to a similar extent on developing products together with suppliers. Therefore, in my subsequent research, I decided to continue this issue.

I presented the effects of initial scientific and research work on cooperation with suppliers during product development in the following publications[30]:

- Wieteska, G. (2014). Importance of suppliers in the New Product Development process. Logistyka, (1), 20-23.
- Wieteska, G. (2016). Włączanie dostawców w rozwój produktów - ewentualność czy już konieczność?, [w:] Bentyn Z., Szymczak M. (ed.), Logistyka i zarządzanie łańcuchem dostaw wobec wyzwań gospodarki światowej, Uniwersytet Ekonomiczny w Poznaniu, 265-278 (at the conference: INTERLOG 2016, Uniwersytet Ekonomiczny w Poznaniu, Poznań).
- Ocicka, B. [50%] & Wieteska, G. [50%] (2016). Otwarte innowacje jako źródło wartości w relacjach z dostawcami [w:] K. Rutkowski (ed.), Zarządzanie łańcuchem dostaw w XXI wieku. W poszukiwaniu nowych źródeł przewagi konkurencyjnej, Szkoła Główna Handlowa w Warszawie, 129-147 (at the conference: Konferencja „Zarządzanie łańcuchem dostaw – w poszukiwaniu nowych źródeł przewagi konkurencyjnej", Szkoła Główna Handlowa w Warszawie, Warszawa, 23.06.2016-24.06.2016).
- Wieteska, G. (2016). Modele współpracy dostawca–nabywca w zakresie rozwijania zielonych produktów. Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach, nr 267, 175-188.
- Wieteska, G. (2017). ESI in the supply chain of modular products. Problemy Transportu i Logistyki, 39(3), 129-140.
- Wieteska, G. (2019). Practical considerations on JPD: developing products with suppliers. Ekonomika i Organizacja Przedsiębiorstwa, (1), 50-63.

[30] The issue of collaboration with suppliers in product development was the subject of research in two grants I received: 1. Grant for young scientists to implement a research topic titled "Early involvement of suppliers in the development of green products" (2015) 2. Grant from National Science Center titled. „Flexibility in relationships with suppliers in terms of supplier-purchaser models of cooperation on product development in the B2B market" (2017-2020).

Assumptions of my NCN project entitled „Flexibility in relationships with suppliers in terms of supplier-purchaser models of cooperation on product development in the B2B market" (2017-2020), which constituted an important part of the research I conducted as part of the publication series, I presented at an international conference (with publication):

- Wieteska, G. (2018). The influence of SI on the flexibility of relationships with suppliers – research framework, [w:] (ed.), ENTERPRISE AND COMPETITIVE ENVIRONMENT Conference Proceedings (978-8-0750-9561-9), Wydawnictwo Mendel University in Brno, Brno 2018, s. 704-716, https://ecos.mendelu.cz/wcd/w-rek-ece/ece2018_fin.pdf (at conference: 21st International Scientific Conference "Enterprise and Competitive Environment", Brno, Czechy, 23.03.2018-24.03.2018).

In 2019, I presented my first results of a systematic literature review (126 publications from 1989-2018) on the supplier involvement in product development in a study that was accepted for presentation at a prestigious international conference *Council of Supply Chain Management Professionals*:

- Wieteska, G., presentation entitled pt. "Supplier involvement in product development: a systematic literature review and future research", 14th European Research Seminar (ERS) on Logistics and SCM, Warszawa, 16.05.2019-17.05.2019.

In order to deepen my knowledge about contemporary practices aimed at improving cooperation in the supply chain, together with dr Barbara Ocicka, I also conducted a qualitative study and developed the following publications on the role of *e-commerce* and *sharing economy* in supply chain management[31]:

- Ocicka, B. [50%] & Wieteska, G. [50%] (2016). E-commerce jako narzędzie budowania relacji w łańcuchu dostaw. Przedsiębiorczość i Zarządzanie, 17(12), 279-294 (at the conference: 4th International Conference "Logistics Systems in Economy - IT solutions, Zielona Góra, 29.09.2016-30.09.2016).
- Ocicka, B. [50%] & Wieteska, G. [50%] (2017). Sharing economy in logistics and supply chain management. LogForum, 13(2), 183-193.

Together with dr Barbara Ocicka, we have also developed a method for measuring relational capital in supply chains[32]. For this purpose, we used my previous experience in conducting a systematic literature review. We presented the research results during the foreign conference "8th

[31] Participation in statutory research of the Department of Logistics, Faculty of Management, University of Lodz: research task entitled "Improving relationships with partners in the supply chain" (2015-2016).
[32] Participation in statutory research of the Department of Logistics, Faculty of Management, University of Lodz: research task entitled "The role of modern technologies in logistics"(2017-2018).

International Conference on Operations and Supply Chain Management (OSCM)", which took place at Cranfield University (Great Britain), 09.09.2018-12.09.2018. We received an *award* for the best presentation at the conference, and the article was published in a foreign journal:

- Ocicka, B. [50%] & Wieteska, G. [50%] (2019). An exploration of the measurement of relational capital in supply chains. Operations and Supply Chain Management: An International Journal, 12(3), 143-152, IF 2023: 3.6.

4.5.2.2 The second research stream – Resilient and sustainable supply chains

The second research stream covered two issues in parallel, which in the last two years I have been combining with each other by searching for mutual relations between them. The first issue is risk management and resilience of supply chains, while the second is the sustainable development of supply chains. I implemented these issues in international and domestic projects, and presented the results of my research in numerous publications, at scientific conferences in Poland and abroad, during lectures in foreign scientific centers, as well as at expert sessions for business practitioners.

Due to scientific and research achievements in the field of supply chain risk management, I was invited by dr hab. Maciej Szymczak, prof. UEP for the cooperation in project financed by National Science Center, entitled „Outsourcing and offshoring in supply chains: information and risk management and the level of supply chain maturity according to the Poirier model" (2011-2012). Together with dr hab. Maciej Szymczak, prof. UEP, dr Anna Baraniecka i dr Mariusz Szuster we designed and conducted a quantitative study. It was crucial for us to identify how manufacturing companies that implement an offshoring or outsourcing strategy manage risk and information, depending on the level of supply chain maturity. I was responsible for the research assumptions related to the risk management process, including the issues of threats identification and risk treatmemt. According to the obtained research results, internal integration dominated in the supply chains of the surveyed enterprises. Managers, however, despite being aware of various threats accompanying the implemented strategies, indicated monitoring and control as the main method used to mitigate the risk. The result of quantitative research conducted together with scientists from the Poznań University of Economics and the Wrocław University of Economics was a monograph titled „Managing Towards Supply Chain Maturity Business Process Outsourcing and Offshoring", published in English by Palgrave Macmillan. I wrote two chapters, and one chapter co-authored:

- Wieteska, G. (2013). Supply Chain Risk, [in:] M. Szymczak (ed.), Managing Towards Supply Chain Maturity Business Process Outsourcing and Offshoring, Palgrave Macmillan, Basingstoke, 87-105.
- Wieteska, G. (2013). Supply Chain Risk Management, [in:] M. Szymczak (ed.), Managing Towards Supply Chain Maturity Business Process Outsourcing and Offshoring, Palgrave Macmillan, Basingstoke, 133-159.

- Szymczak, M. [25%], Szuster, M. [25%], Wieteska, G. [25%], & Baraniecka, A. [25%] (2013). Supply Chain Management, [in:] M. Szymczak (ed.), Managing Towards Supply Chain Maturity Business Process Outsourcing and Offshoring, Palgrave Macmillan, Basingstoke, 9-44.

In 2014, for the book entitled "Managing Towards Supply Chain Maturity Business Process Outsourcing and Offshoring" we received the first-degree team *award* of the Rector of the Poznań University of Economics.

As part of the same project, we also conducted a qualitative study, which resulted in the development of case studies presenting methods of managing international supply chains against the background of the recognized level of maturity. This part of the work resulted in another monograph in which I prepared a chapter on offshoring risk management and three case studies:

- Wieteska, G. (2014). Zarządzanie ryzykiem offshoringu, [w:] M. Szymczak (ed.), Offshoring a rozwój łańcuchów dostaw, Uniwersytet Ekonomiczny w Poznaniu, Poznań, 73-96.
- Wieteska, G. (2014). Polski producent wyrobów z laminatów poliestrowo-szklanych (studium przypadku) [in:] M. Szymczak (ed.), Offshoring a rozwój łańcuchów dostaw, Uniwersytet Ekonomiczny w Poznaniu, Poznań, 108-115.
- Wieteska, G. (2014). Producent zbiorników ciśnieniowych pod globalną marką (studium przypadku) [in:] M. Szymczak (ed.), Offshoring a rozwój łańcuchów dostaw. Uniwersytet Ekonomiczny w Poznaniu, Poznań, 129-134.
- Wieteska, G. (2014). Przedsiębiorstwo w zakresie kolejnictwa – jednostka międzynarodowego koncernu (studium przypadku) [in:] M. Szymczak (ed.), Offshoring a rozwój łańcuchów dostaw. Uniwersytet Ekonomiczny w Poznaniu, Poznań, 142-146.

The inter-university cooperation in this NCN project also resulted in the following publications presented at conferences::

- Szuster, M. [50%] & Wieteska, G. [50%] (2011). Identyfikacja zagrożeń międzynarodowych w usługach logistycznych. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, numer 235, Strategie i logistyka w sektorze usług: strategie na rynku TSL, 63-73 (at conference: Strategie i logistyka w sektorze usług", Katedra Zarządzania Strategicznego i Logistyki, Uniwersytet Ekonomiczny we Wrocławiu, 16.10.2011-18.10.2011).
- Baraniecka, A. [20%], Jajko-Siwek, A. [20%], Szuster, M. [20%], Szymczak, M. [20%], & Wieteska, G. [20%] (2017). Relativism in the approach to managing supply chain maturity. Procedia Engineering, 182, 50-57 (at conference: The 7th EPPM Conference, Faculty of Management, Bialystok University of Technology, Association of Engineering, Project, and Production Management, and the International Society for Manufacturing, Service and Management, Białystok, 21.09.2016-23.09.2016).

I also tried to regularly update my knowledge supply chain risk management. I was interested in, among others: recognizing the issue of risk in B2B portfolio models[33]:

- Wieteska, G. (2013). Portfolio models of B2B relationships – barriers to supplier risk management, Proceedings of the 18th International Symposium on Logistics, 2013, 170-176. https://islconf.org/wp-content/uploads/pdf/18thISLProceedings-Vienna-Austria.pdf (at conference: International Symposium on Logistics (ISL) 2013, Wiedeń, Austria, 07.06.2013-10.06.2013).
- Wieteska, G. (2014). Supplier risk in building B2B relationships–portfolio models approach. International Journal of Supply Chain and Operations Resilience, 1(1), 104-120.
- Wieteska, G. (2017). Zarządzanie ryzykiem w łańcuchu dostaw-kierunki zarządzania ryzykiem w przedsiębiorstwie - cz. 1. Problemy Jakości, (10), 24-30.
- Wieteska, G. (2017). Zarządzanie ryzykiem w łańcuchu dostaw - kierunki zarządzania ryzykiem w relacjach z dostawcami - cz. 2. Problemy Jakości, 49(11), 28-34.

I have observed that risk management strategies (in terms of anticipation and response) include, among others: strategies to increase flexibility, therefore, my research also focused on the flexibility, adaptability and resilience of supply chains[34]:

- Wieteska, G. (2014). Skuteczne reagowanie na zakłócenia–elastyczny łańcuch dostaw. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, (382), 143-153 (at conference: Strategie i logistyka w warunkach kryzysu", Katedra Zarządzania Strategicznego i Logistyki, Uniwersytet Ekonomiczny we Wrocławiu, Jelenia Góra 19.10.2014-21.10.2014).
- Wieteska, G. (2015). Responding to the disruptions effectively – research results on the supply chain flexibility, Pawar K.S, Rogers H., & Ferrari E. (ed.) https://www.islconf.org/wp-content/uploads/2015/07/20th-ISL-2015-abstract-proceeding.pdf (at conference: 20th International Symposium on Logistics (ISL) 2015 "Designing Responsible and Innovative Global Supply Chains", Bolonia, Włochy, 05.07.2015-08.07.2015).

[33] The issues were the subject of qualitative and quantitative research carried out as part of:1. An independent grant for young scientists entitled "Directions of development of supplier relationship management strategies in the light of supplier-client relationship portfolio models" (2013) 2. Participation in statutory research of the Department of Logistics, Faculty of Management, University of Lodz: research task titled "The role of quality, environmental and safety management systems in improving processes in the supply chain" (2011-2014). 3. Grant from the National Science Center that I received for the implementation of the project entitled " Flexibility in relationships with suppliers in terms of supplier-purchaser models of cooperation on product development in the B2B market " (2017-2020).

[34] The issues were the subject of qualitative and quantitative research carried out as part of: 1. Team grant for young scientists entitled "The place and role of Polish enterprises in international supply chains" (2014) 2. Participation in statutory research of the Department of Logistics, Faculty of Management, University of Lodz: research task titled "The role of quality, environmental and safety management systems in improving processes in the supply chain" (2011-2014) 3. Grant from the National Science Center that I received for the implementation of the project entitled " Flexibility in relationships with suppliers in terms of supplier-purchaser models of cooperation on product development in the B2B market " (2017-2020).

- Wieteska, G. (2016). Relacje z dostawcami na miarę XXI wieku - elastyczne i adaptacyjne. Logistyka, (2), 26-30.
- Wieteska, G. (2016). Building resilient relationships with suppliers in the B2B market. Management, 20(2), 307-321.
- Wieteska, G. (2016). Elastyczność relacji z dostawcami w erze turbulencji. Gospodarka Materiałowa i Logistyka, (3), 9-15.
- Wieteska, G. (2017). Ensuring the flexibility and continuity of supplies in the B2B market. Journal of Economics and Management, (29), 118-138 (at conference: Building the Supply Chains of the Future, Uniwersytet Ekonomiczny w Katowicach, Katedra Logistyki Ekonomicznej, Katowice, 26.09.2016-27.09.2016).

As part of the first issue in the discussed research stream, I also conducted research on security and business continuity management in the supply chain[35]. They were a continuation of research on risk management, but focused on the uncertainty which source is changing environment, as well as on responding to realized risk, i.e. on the disruption phase and on the post-disruption phase. In the research conducted, I also identified the most important sources of uncertainty accompanying purchases (e.g., pressure to reduce costs and to look for cheaper sources of supply, fluctuations in commodity prices and currency exchange rate fluctuations, mall number of suppliers in the market, negotiating advantage of suppliers) and the main practices that are implemented by enterprises in response to the increasing variability of the internal and external environment of supply chains (e.g., reconfiguring the structure and resources of the supply chain, conducting Business Impact Analysis, increasing adaptability and building supply chain resilience). Moreover, Business Impact Analysis, I identified the impact of disruptions on the functioning of supply chains:

- Wieteska, G. (2011). Bezpieczeństwo w sieci dostaw, Acta Universitatis Lodziensis. Folia Oeconomica, numer 258, 149-162.
- Wieteska, G. (2012). Risk Management in Relations with Suppliers as a Tool for Building the Safety and Business Continuity in Supply Chains (at conference: 18th IGWT Symposium - Technology and Innovation for a Sustainable Future: a Commodity Science Perspective, Rzym, Włochy, 24.09.2012-28.09.2012).

[35] The issues were the subject of qualitative and quantitative research as part of: 1. Participation in statutory research of the Department of Logistics, Faculty of Management, University of Lodz: research task titled "The role of quality, environmental and safety management systems in improving processes in the supply chain" (2011-2014) 2. Team grant for young scientists entitled „Improving processes in the supply chain" (2011) 3. Team grant for young scientists entitled „The place and role of Polish enterprises in international supply chains" (2014) 4. An independent grant for young scientists entitled „Supply chain strategies in an era of increasing environmental turbulence" (2016).

- Wieteska, G. (2015). Niepewność otoczenia towarzysząca zakupom na rynku B2B. Logistyka, (3), 5842-5848 (at conference: VI International Scientific Logistics Conference WSL FORUM, WSL Poznań, 15.05.2015-15.05.2015).
- Wieteska, G. (2015). Environmental uncertainty accompanying purchases in the B2B market. Procedia - Social and Behavioral Sciences, 213, 911-917 (at conference: 20th International Scientific Conference Economics and Management (ICEM) 2015, Kowno, Litwa, 06.05.2015-08.05.2015).
- Wieteska, G. (2018). Business Impact Analysis of supply chain disruptions, https://www.dpublication.com/proceeding/8th-icmeh/#Table-of-Contents (at conference: The 8th International Conference on Management, Economics and Humanities, Barcelona, Hiszpania, 07.12.2018-09.12.2018).
- Wieteska, G. (2019). Supply chain redesign for resilience - the perspective of the consequences of disruption, Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław, 63(4), 122-139 (at conference: „Ekonomiczne i społeczne uwarunkowania rozwoju gospodarki w teorii i praktyce" Jubileusz 50-lecia Wydziału Ekonomii, Zarządzania i Turystyki w Jeleniej Górze, Uniwersytet Ekonomiczny we Wrocławiu 04.09.2019-06.09.2019, Karpacz).

I presented the results of research on risk, resilience and supply chain management in a variable and uncertain environment not only in domestic and foreign journals and at national and international conferences. I also presented the results of my research during lectures at the following foreign research institutions: Polytechnic Institute of Porto (Portugal) and University of Aveiro (Portugal), Cantabria University (Spain), Kaunas University of Technology (Lithuania), as well as during sessions for business practitioners (Infosys Poland, LODZistics Logistyczna Sieć Biznesowa Polski Centralnej, DEKRA Group).

I also gradually expanded my knowledge and competences in supply chain management, risk management and business continuity. An example of specific achievements is completing my exams with positive results, which allowed me to obtain the following certificates:

- 2019, Certificate "Business Continuity Management Systems (BCMS) Auditor/Lead Auditor ISO 22301:2012", BSI Training Academy, Warsaw.
- 2017, Certificate "BSCI: APICS CPIM – Basics of Supply Chain Management" 17/12/2017.

The second issue in the described research stream focused on sustainable supply chain management. It was the main subject of research on international projects and scientific papers presented at foreign scientific conferences. The issue of sustainable development was analyzed in both environmental and social contexts.

The environmental context dominated in the international project entitled „Promoting Environmentally Sustainable SMEs (PrESS)" (2013-2015) and in the international project titled

"TrainERGY - Training for Energy Efficient Operations" (2015-2018). The aim of the first project was to identify and assess the scope of application of the so-called Green Practices in the area of sustainable development by small and medium-sized enterprises in Poland, Great Britain, Italy and Greece. The results were presented in the following publications:

- Kalinowski, T. B. [33,33%], Rudnicka, A. [33,33%], & Wieteska, G. [33,33%] (2016). Zarządzanie emisjami CO_2 w łańcuchach dostaw wybranych produktów. Ekonomika i Organizacja Przedsiębiorstwa, 9, 72-87.
- Kalinowski, T. B. [33,33%], Rudnicka, A. [33,33%], & Wieteska, G. [33,33%] (2016). Praktyki prośrodowiskowe wspierające rozwój zrównoważony w łańcuchu dostaw w wybranych krajach europejskich. Gospodarka Materiałowa i Logistyka, (4), 2-12.
- Kalinowski, T. B. [33,33%], Rudnicka, A. [33,33%], & Wieteska, G. [33,33%] (2017). CO_2 hotspots identification in supply chains of different products. Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach, (321), 69-82 (at conference: Building the Supply Chains of the Future, Uniwersytet Ekonomiczny w Katowicach, Katedra Logistyki Ekonomicznej, Katowice, 26.09.2016-27.09.2016).

The aim of the second project was to examine the competences of employees of companies from the countries participating in its implementation in the area of applying the concept of sustainable development and activities for energy efficiency. Consequently, the study contributed to the development of a matrix defining competence gaps and the creation of a virtual educational environment that addressed them (https://www.trainergy-project.eu/language/en/virtual-learning-environment). The project results were presented at international conferences (and published in Proceeding in co-authorship with foreign partners) in: Poznań (Poland), Ljubljana (Slovenia), Thessaloniki (Greece), Brno (Czech Republic), London (Great Britain) and Barcelona (Spain). They also contributed to the creation of a scientific article published in an international journal, as well as a chapter in a monograph:

- Kalinowski, T. B. [10%], Wieteska, G. [10%], Rudnicka, A. [10%], Wronka, A. [10%], Solomon, A. [10%], Piccolo, C. [10%], Diglio, A. [10%], Bruno, G. [10%], Koh, S. C. L. [10%] & Genovese, A. [10%] (2018). The process of gaining key competencies in the implementation of energy efficient and sustainable supply chain operations. International Journal of Innovation and Regional Development, 8(3), 232-258.
- Kalinowski, T. B. [25%], Rudnicka, A. [25%], Wronka, A. [25%], & Wieteska, G. [25%] (2020). Proces zdobywania kluczowych kompetencji wspierających wdrożenie zrównoważonego łańcucha dostaw, [in]: Nowoczesne trendy w logistyce i zarządzaniu łańcuchem dostaw, Brzeziński J., Rudnicka A. (ed.), University of Lodz, Lodz, 93-105.

An important element of both described projects (as well as international projects co-financed, awarded by the Ministry of Science and Higher Education in a competitive manner, which were implemented together with them, i.e.: "Promotion of environmental management and sustainable

development in the SME sector" and "Development of competences in the field of sustainable development and efficiency energy") was research of an application nature, including in particular research and development work in the field of platform *Supply Chain Environmental Analysis Tool* (SCeNAT) development, which supports companies in making decisions regarding reducing their negative impact on the natural environment, including reducing carbon dioxide consumption throughout the entire supply chain of a given product. Work on the platform was initiated by the University of Sheffiled in 2012. Thanks to both projects discussed, I took part in activities aimed at testing and improving them. I also conducted training on the structure, use and application of the advanced SCeNAT tool in relation to the following stages:

1. Development of a supply chain map including input elements and processes.
2. Supply Chain Carbon Map Calculation.
3. Identification of change scenarios that will result in emission reductions CO_2.
4. Using calculations to select the most optimal solutions to reduce emissions CO_2.

The described analytical tool uses methods and techniques such as process mapping and measurement CO_2, assessment of supply chain performance using economic and environmental Key Performance Indicators. The methodology discussed is based primarily on traditional product life cycle assessment, with the use of Multi-Regional Input-Output Analysis (MRIO) method, indicating the amount of CO2 emissions generated by other sectors of the economy that are involved in the supply chain of the analyzed product.

As a result of the implementation of the above-described projects in the field of sustainable development, as well as professional experience in the field of product design in the supply chain, I became scientifically interested in the relationship between the product life cycle and reducing the negative impact on the natural environment through cooperation in the supply chain. I presented research on this topic, among others, in this publication series.

While examining the impact of product design on the structure and resources of the product's supply chain in relation to the environmental dimension of sustainable development, I also undertook research on cosmetics supply chains. The reason for choosing this sector is my long-term, private interest in the development of new technologies in cosmetology, as well as completed postgraduate studies at the Lodz University of Technology (Cosmetology, Faculty of Biotechnology and Food Sciences). In my research, I recognized and described the impact of introducing natural and organic cosmetics to the market on the reconfiguration of cosmetics supply chains:

- Wieteska, G. (2018). The impact of the development of natural and organic cosmetics on supply chain processes and supplier base architecture, [in:] (ed.), Book of Proceedings ICoM 2018, 8th International conference on management "Leadership, Innovativeness and Entrepreneurship in a Sustainable Economy", Wydawnictwo Wydziału Zarządzania Politechniki Częstochowskiej, Częstochowa, 648-653 (at conference: 8th International Conference on Management

"Leadership, Innovativeness and Entrepreneurship in a Sustainable Economy ICoM, Politechnika Częstochowska, 07.06.2018-08.06.2018).

- Wieteska, G. (2019). Supply chain redesign for resilience - the perspective of the consequences of disruption, Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Wrocław, 63(4), 122-139.

Started with dr. hab. Lucyna Witek, prof. PRz scientific relationship during the international conference ICoM 2018 became a reason to conducting international comparative research in the field of sustainable purchases of cosmetic products, entitled "Consumer behavior on the natural cosmetics market in Poland and Ukraine." We conducted considerations, both in the environmental and social dimensions. Using extended theory of planned behaviour and structural equation modeling, we identified that in both studied countries attitude towards purchasing natural cosmetics, social norms, consumers' innovativeness and consumer's natural cosmetics knowledge all have statistically significant and positive impacts on the purchase intention towards natural cosmetic products. The result of the joint work was the following scientific article (my contribution concerned: designing the assumptions and conducting the study, conceptualizing the article based on the literature review, methodology, developing the discussion and conclusions):

- Witek, L. [30,33%], Kędzia, G. [30,33%], & Staniec, I. [33,33%] (2023). Towards sustainable purchase: the effect of social responsibility, innovativeness and knowledge of natural cosmetics purchasing consumers' intentions. Economics and Environment, 4 (87), 1-28.

The social context dominated my research, also in the international project entitled „ELIEMENTAL: Breaking Down Barriers to Enterprise", in which I was a project manager at the University of Lodz (2013-2015). Its aim was to identify socio-cultural barriers to entrepreneurship using the Participatory Action Research (PAR) method, and developing and testing effective learning tools, supported by online mentoring systems, for the development and application of entrepreneurial skills. The target groups of the project were women over 40 who were professionally inactive for a long time, young people without high education or professional experience, and ethnic minorities. In the project, I was responsible for identifying socio-cultural barriers to entrepreneurship in our country. I carried out in-depth qualitative research in this area, in which I used the focus group method (and the innovative Ketso Toolkit group work tool), as well as the method of individual in-depth interviews. As a result, I also developed case studies in which I described socio-cultural barriers to the development of entrepreneurship among women from the +40, +50 and +60 groups.

The project was also focused on the development and application of new products. At the international level, I was responsible for creating and testing a mentoring program in which representatives of target groups became mentors. I also participated in work aimed at developing an effective educational tool and creating opportunities to validate the competences of target groups using the Enterprise Learning platform. Another important development task I completed was to

create a network with a virtual map of meeting places for target groups (*Community Access Points*, CAPS), which had the greatest potential for implementing a mentoring program. The project itself also developed my social skills to a large extent. Personally, I treat the process of building trust and bonds with representatives of researched target groups as a unique experience.

The socio-economic context was the subject of subsequent research, this time carried out in the international project entitled „FOLPSEC: Functioning of the Local Production Systems in the Conditions of Economic Crisis (Comparative Analysis and Benchmarking for the EU and Beyond)" (2012-2015). Its aim was to identify and transfer best practices in the operation and stimulation of the development of local production systems, as well as to develop methods for studying them. During the two research fellowships (the first in Novosibirsk State University and the second in Ternopil National Economic University), together with scientists from partner universities, we conducted in-depth considerations on the motivators and activators of the development of sustainable local production systems, as well as mechanisms of economic cooperation between enterprises, authorities, scientific and research institutes, non-governmental organizations and other entities operating in small territorial systems. At the international level, we also exchanged knowledge and experience in designing and conducting research on complex economic systems, including clusters. In the project, I was particularly interested in issues related to shaping a safe space for the socio-economic development of local production systems. Together with dr Beata Wieteska-Rosiak from the Faculty of Economics and Sociology of the University of Lodz, I conducted a study in this area, which was published in a monograph that was the main result of the entire project:

- Wieteska, G., Wieteska-Rosiak, B. (2014). Shaping a safe public space in accordance with the principles of CPTED concepts: sense of safety in Akademgorodok, [in:] A. Novoselov, V. Seliverstov (ed.), Local Productions Systems and Regional Economic Development, Wydawnictwo Institute of Economics and Industrial Engineering, Novosibirsk, 176-186.

In 2015, I was *awarded* by Foundation of the University of Lodz for special scientific achievements in 2013-2014 in the area of social sciences in a group of young researchers at the University of Lodz.

I also addressed the issue of shaping safe space in cities and regions in another study. Since the resilience of logistics systems depends largely on the socio-environmental safety of the enterprises' locations, the next subject of consideration was the identification and assessment of the maturity of social innovations for the adaptation of cities to climate change. Together with other scientists, I recognized that the key source of creating this type of social innovations is: local politics, the local community and non-governmental organizations. However, there is a need to integrate activities and a strong interdependence between top-down and bottom-up innovations. Based on the maturity

model of the innovation development process, we assessed that our country is at the fourth of its six levels. Entering a higher level requires, above all, an integrated approach and inclusion in the development of innovations of the private sector, as well as increasing the level of involvement of the public sector. The research effects, in which I was co-responsible for the implementation of each stage, are described in the chapter of the monograph published by Taylor & Francis Group:

- Wieteska-Rosiak, B. [33,33%], Wieteska, G. [33,33%], & Ocicka, B. [33,33%] (2022). The Maturity of Social Innovations for the Adaptation of Cities to Climate Change–The Case of Poland [in:] U. Chatterjee, A. Biswas, J. Mukherjee, S. Majumdar (ed.), Advances in Urbanism, Smart Cities, and Sustainability, Taylor & Francis Group, Philadelphia, 137-157.

The second research stream covered two types of issues that I described above, i.e. supply chain resilience and supply chain sustainable development. In the last two years, using the acquired knowledge and experience, I have been combining them, looking for relations between them. The result of this direction is quantitative research titled: "Sustainable and resilient supply chains" conducted in 2022, together with dr hab. Blanka Tundys, prof. US and dr Tomasz Wiśniewski from the University of Szczecin. In our several years of scientific and research cooperation, I am responsible for substantive contributions in the field of risk management, as well as strategies, capabilities and practices of resilient supply chains. I also use the knowledge and experience derived from previously completed projects on sustainable development, as well as full-time master's studies in Environmental Protection.

Thanks to our research using the CATI technique, in which I was responsible for developing the part of the questionnaire related to supply chain resilience and sustainable development risk management, we built and verified a model examining the impact of internal and external sustainable development practices on the three main capabilities of a resilient supply chain, i.e. the ability to anticipate risk, the ability to respond to disruptions, and the ability to recover from disruption. We confirmed, among others: the positive impact of sustainable internal practices on each of the three resilient supply chain abilities, and the positive impact of sustainable external practices on the ability to anticipate and ability to respond to disruption. When developing the research assumptions and analyzing the collected data, I also used my experience in structural equation modeling. The effects of the work, including the developed "sustainable supply chain 2.0 model", were presented in a joint monograph, published in English by Palgrave Macmillan:

- Tundys B. [25%], Kędzia G. [25%], Wiśniewski T. [25%] & Ziołо M. [25%] (2024), Sustainable Supply Chains 2.0: Towards Environmental, Social, and Economic Resilience, Palgrave Macmillan, London.

As part of the continuation of the analyzes of the collected data, we also observed significant relationships between the degree of implementation of the principles of sustainable development in the supply chain processes and the supply chain resilience to sustainability risk in terms of risk

anticipation, risk response and return to balance along with post-event learning. Work on this issue will be presented at the 10th Scientific and Economic Conference " Odpowiedzialne łańcuchy dostaw 2024" in Toruń and will become the subject of a scientific article that we want to submit to an international journal.

4.5.2.3. The third research stream – Supply chains in a circular economy

In the third research stream, I dealt with the issue of supply chain management in accordance with the principles of the circular economy. I conducted research in this area in two sectors: the packaging sector and the food sector.

Research relationships established during the 2018 conference (8th International Conference on Operations and Supply Chain Management, Cranfield University, Wielka Brytania, 09.09.2018-12.09.2018) resulted in the invitation I received from prof. Benny Tjahjono (Coventry University, Coventry, Wielka Brytania) to cooperate with scientists from Simon Fraser University (Canada) and the Federal University of São Carlos (Brazil) on applying for a grant for the implementation of an international project entitled „New Frontiers in Social Innovation Research: Social Innovation Management for BIOPlastics (SIMBIO)" (2020-2023). In the project, I served as a project manager at the University of Lodz, managing the team and participating in the implementation of all planned goals and tasks. The project in our country received funding from the National Center for Research and Development. The partner of the University of Lodz in Poland was the Warsaw School of Economics.

The international work in the SIMBIO project was of a research and development nature. Their implementation in Poland would not be possible without partnership relationships with stakeholders in the food bio-packaging supply chains, which (despite the ongoing COVID-19 pandemic) were established and developed by the SIMBIO Polska team during the entire project. The research part of the work carried out in the project was aimed at identifying the conditions for the development of the bioplastic packaging market, including compostable packaging, considered as potentially the most ecological alternative to conventional packaging.

In-depth interviews (31 in total) with representatives of internal and external supply chain stakeholders (implementing subsequent stages of the bio-packaging life cycle) became a source of a broad diagnosis of the market, including information on the activators and barriers to market development in the circular economy. They also allowed to understand the interdependencies, risks and challenges emerging in national and international bio-packaging supply chains. Particularly interesting was the analysis of identified barriers using Ishikawa diagrams and the "5 Whys" method, which resulted in reaching their root causes.

The development part of the project was focused on the development of solutions that would enable the elimination of key barriers and their causes and, consequently, stimulate the development

of the food bio-packaging market in accordance with the circular economy principles of the 3R (*Reduce*, *Reuse*, *Recycle*). During discussion panels integrating stakeholders from the private, public and non-governmental (social) sectors, we carried out the *design* and then *rapid prototyping* of three main solutions, which were selected from among several dozen as those with the greatest potential impact on the market. These included solutions aimed largely at market integration: developing a national strategy for the development of the compostable packaging market, establishing an industry organization and creating a B2B technological platform. We have determined their main features and functionalities as well as the resources necessary for development and implementation. In addition, we proposed entities that should participate in the application of solutions, as well as potential sources of financing related activities. We also indicated the desired effects of using these solutions, as well as assessed the associated risks.

In the SIMBIO project, one can see a substantive connection between the management of subsequent stages of the closed product life cycle and supply chain processes. I also used this approach when developing case studies in the monograph, which is part of the publication series.

The results of the research and development work of the SIMBIO project were included in four extensive industry reports in Polish and four short reports in English, which I co-created and was responsible for their structure and content as a project manager at the University of Lodz. (https://www.simbioresearch.com , https://www.wz.uni.lodz.pl/simbio):

- Brzeziński, J. [16,66%], Marzantowicz, Ł. [16,66%], Ocicka, B. [16,66%], Tyczyna, E. [16,66%], Wieteska, G. [16,66%] & Wieteska-Rosiak, B. [16,66%] (2021). Raport branżowy „Identyfikacja wyzwań dla zastosowania opakowań z bioplastiku".
- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2021). Raport branżowy „Analiza i zrozumienie problemów dla zastosowania opakowań z bioplastiku",
- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2022). Raport branżowy „Projektowanie potencjalnych rozwiązań dla zastosowania opakowań z bioplastiku",
- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2023). Raport branżowy „Szybkie prototypowanie potencjalnych rozwiązań dla zastosowania opakowań z bioplastiku".
- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2021). „Executive Summary: Defining the convening questions".

- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2021). „Executive Summary: Understanding the problem".
- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2022). „Executive Summary: Designing potential solutions".
- Brzeziński, J. [14,28%], Ocicka, B. [14,28%] Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], Wieteska, G. [14,28%] & Wieteska-Rosiak, B. [14,28%] (2022). „Executive Summary: Prototyping solutions".

Moreover, together with the project partners, I developed a White Paper in which the effects of research and development work at the international level were presented:

- Li, B. [12,5%], Soma, T. [12,5%], Beltran, M. [8,33%], Lazell, J. [8,33%], Tjahjono, B. [8,33%], Kędzia G. [12,5%], Ocicka, B. [12,5%], Roncalho de Lima, L. [8,33%], Gutierrez R. F. [8,33%], Cruz, S.A. [8,33%] (2023). „White Paper: New Frontiers in Social Innovation Research".

The report, on the Polish side, also includes comments from team members: dr Beata Wieteska-Rosiak, dr Jolanta Turek, dr Marta Raźniewska.

The SIMBIO project also included two scientific seminars, in which I acted as the chairperson and organizer from the University of Lodz:

- Scientific seminar „Opakowania kompostowalne – innowacje dla potrzeb rozwoju rynku opakowań do żywności", Warsaw School of Economics and University of Lodz, Warszawa, 23.09.2022. The scientific seminar aimed to integrate internal and external stakeholders in the supply chains of compostable packaging in our country.
- Scientific seminar Kolegium Nauk o Przedsiębiorstwie SGH oraz Wydziału Zarządzania UŁ „Determinanty rozwoju rynku bioopakowań w gospodarce o obiegu zamkniętym", 18.06.2021, (online), Warsaw School of Economics and University of Lodz. The seminar was international in nature and its task was to start a discussion on the conditions for the development of the bio-based food packaging market in our country and at the transcontinental level.

The project also resulted in participation in numerous domestic and foreign conferences, where I presented the effects of our work, as well as publications, including two in foreign journals with IF:

- Brzeziński, J. [16,66%], Marzantowicz, Ł. [16,66%], Ocicka, B. [16,66%], Tyczyna, E. [16,66%], Wieteska, G. [16,66%] & Wieteska-Rosiak, B. [16,66%] (2021). Łańcuchy dostaw bioopakowań w gospodarce o obiegu zamkniętym – koncepcja badań. Marketing i Rynek, (3), 3-13.
- Kędzia, G. [50%], & Turek, J. [50%] (2022). What Hinders the Development of a Sustainable Compostable Packaging Market?. European Journal of Sustainable Development, 11(4), 180-180.

- Kędzia, G. [16,66%], Ocicka, B. [16,66%], Pluta-Zaremba, A. [16,66%], Raźniewska, M. [16,66%], Turek, J. [16,66%], & Wieteska-Rosiak, B. [16,66%] (2022). Social Innovations for Improving Compostable Packaging Waste Management in CE: A Multi-Solution Perspective. Energies, 15(23), 1-19. IF 2023: 3.0. Za tą publikację otrzymałam w roku 2023 *wyróżnienie* za najwyżej punktowaną publikację w roku 2022-2023 na Wydziale Zarządzania UŁ.
- Brzeziński, J. [14,28%], Kędzia, G. [14,28%], Ocicka, B. [14,28%], Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], & Wieteska-Rosiak, B. [14,28%] (2022). Diagnoza i perspektywy rozwoju rynku bioopakowań w gospodarce o obiegu zamkniętym. Marketing i Rynek, (9), 27-38.
- Brzeziński, J. [14,28%], Kędzia, G. [14,28%], Ocicka, B. [14,28%], Pluta-Zaremba, A. [14,28%], Raźniewska, M. [14,28%], Turek, J. [14,28%], & Wieteska-Rosiak, B. (2023). Opakowania kompostowalne-innowacje dla potrzeb rozwoju rynku opakowań do żywności. Relacja z seminarium naukowego projektu SIMBIO. Marketing i Rynek, (1), 38-42.
- Ocicka, B. [33,33%], Kędzia, G. [33,33%], & Brzeziński, J. [33,33%] (2023). State of the art and future scenarios for bio-packaging market transition: evidence from Poland. International Journal of Emerging Markets, vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJOEM-10-2022-1614 IF 2023: 2.7.

The project also resulted in articles written in co-authorship with foreign partners. I acted as a leader on the Polish team of co-authors in these articles. The articles present comparative analyzes of the obtained results at the international level. The first of them was submitted to the *Business Strategy and the Environment* (IF 2023: 12.5) and received positive reviews. It is currently in the process of incorporating final comments from reviewers and will soon be sent back to the editors:

- Li, B. [8,33%], Lazell, J. [8,33%], Beltran M. [8,33%], Kędzia, G. [8,33%], Lima, L. R. [8,33%], Soma, T. [8,33%], Cruz, S.A. [8,33%], Francisconi Gutierrez, R. [8,33%], Turek, J. [8,33%], Raźniewska, M. [8,33%], Pluta-Zaremba, A. [8,33%], & Tjahjono, B. [8,33%], Addressing the circular economy challenges of the bio-based plastic packaging sector: Insights from a social innovation lab study in Brazil, Canada, Poland and the UK.

The second article was submitted to the *Journal of Cleaner Production* (IF 2023: 9.7). The editors sent it for reviews:

- Beltran, M. [20%], Kędzia, B. [20%], Ocicka, B. [20%], Wieteska-Rosiak, B. [20%], & Lazell, J. [20%], Assessing the socio-technical transition pathways towards a circular bio-packaging market: A cross-country analysis.

I also combined the topics of circular products and new technologies in a joint study and a chapter of a monograph published by Routledge. In the study, I was responsible for the issue of circular products and developing a case study in the cosmetics sector:

- Ocicka, B. [33,33%], Wieteska, G. [33,33%], & Wieteska-Rosiak, B. [33,33%] (2023). Toward Circular Product Lifecycle Management through Industry 4.0 Technologies. [in:] V. Bali, R. Mohana, A. Elngar, S. Chawla, G. Singh (ed.), Handbook of Sustainable Development Through Green Engineering and Technology. Routledge, Abingdon-on-Thames, 68-106.

The issue of supply chain management in a circular economy was also the subject of research I conducted in an international project „Promoting Circular Economy in the Food Supply Chain, ProCEeds" (2019-2023). As part of the project, I completed a research fellowship (two stays) at the host institution, the Parthenope University of Naples (Italy). The fellowship consisted of implementing a project for the Italian company Agritalia, a distributor of food products on the American market, and developing scientific and research cooperation with foreign scientists, such as prof. Renato Passaro (Parthenope University of Naples) and prof. Andrea Genovese (University of Sheffield, UK).

After identifying the business model and needs of Agritalia, together with dr Marta Raźniewska (Faculty of Management, University of Lodz), we identified the areas of the company's global supply chain that have the greatest potential for introducing the principles of a circular economy (Part I of the fellowship). Then, after analyzing the collected quantitative data (we conducted in-depth interviews with the company's representatives) and analyzing the quantitative data received from the company regarding the flow of goods and information, we chose two directions for improving the company's supply chain along with possible to implement circular solutions, i.e. 1. Introducing eco-design of food packaging in accordance with the principles of a circular economy (including identifying the company's packaging with the greatest potential for improvements, as well as determining the importance of including suppliers and American customers of the company in this process), and 2. Reducing food losses and waste in distribution (including risk management in the storage and transport process, methods of measuring the amount of losses, types of new technologies) (part II of the fellowship). As part of the first direction, I was substantively responsible for identifying the company's product development chain and indicating the possibilities for the company to develop its products in accordance with the Design for Environment approach. As part of the second field of study, I was responsible for the issue of risk management for products (safety and security) in the processes of the flow of physical goods.

The effects of qualitative research conducted on Agritalia's global supply chain are currently the subject of work on an article titled „Sustainable packaging introduction in a transatlantic supply chain – distributor perspective", which, together with scientists from abroad, we plan to submit to the journal in the coming months International Journal of Physical Distribution and Logistics Management. In this study, we present drivers and barriers to transatlantic cooperation on the development, and introduction to the American market, food products in packaging with a reduced negative impact on the natural environment. In this article, I am responsible for, among others: the

issue of development of sustainable packaging in relationships with suppliers and customers, presentation of results and discussion of the results, i.e. identified barriers and drivers at the macro, meso (supply chain) and micro (Agritalia enterprises) levels in relation to research results from the literature on the subject.

Together with dr Marta Raźniewska, we continue cooperation with scientists from the Parthenope University of Naples, i.e. prof. Renato Passaro and dr. Ivana Quinto. We are conducting together a study entitled: "Open innovation, packaging and design for the environment". Its aim is to identify the impact of open innovation on: environmental design, the success of sustainable packaging and reducing the risk of food losses.

In the first half of 2024, we carried out a quantitative study using the CATI technique, we started analyzing the collected data (using advanced statistical methods), and we are currently developing the concept of a scientific article. In research and scientific cooperation, I am responsible in particular for the issues of open innovation and environmental design, as well as the measurement of the studied variables (DfE, the degree of partners' involvement in NPD and the success of sustainable packaging). I also designed a CATI questionnaire and developed proposals for some constructs and theoretical models, which we will verify using the Cronbach's Alpha coefficient and Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM).

4.5.3. Summary of scientific achievements

4.5.3.1. Scientific publications, indicators of scientific achievements, international and national awards and distinctions for scientific activities

In total, I published 98 scientific papers, including 52 in English (26 as the sole author and 26 in co-authorship) and 46 in Polish (34 as the sole author and 12 in co-authorship). A total 9 works were published (in Polish) before obtaining the PhD degree in economics, and 88 works after obtaining the PhD degree in economics, including 71 articles, 3 monographs and 15 chapters (or subchapters) in monographs (Table 10).

Seven scientific articles were published in journals that received the following IF in 2023 (source: Journal Citation Reports):

- *LogForum* (1 paper) – 1.2
- *International Journal for Quality Research* (1 paper in co-authorship) – 1.2
- *Operations and Supply Chain Management-An International Journal* (2 papers, including 1 in co-authorship) – 2.4
- *Central European Management Journal* (1 paper) – 1.3
- *Energies* (1 paper in co-authorship) – 3.0
- *International Journal of Emerging Markets* (1 paper in co-authorship) – 2.7

Table 10. Summary of achievements before and after obtaining a doctoral degree.

Publication type	*Before obtaining PhD*				*After obtaining PhD*				
	As sole author		As co-autor		As sole author		As co-autor		
	PL	Eng.	PL	Eng.	PL	Eng.	PL	Eng.	**Together**
Scientific monographs	-	-	-	-	2	-	-	1	**3**
Chapters in monographs	-	-	-	-	5	4	2	4	**15**
Scientific articles in national journals	6	-	-	-	18	11	6	3	**44**
Scientific articles in foreign journals	-	-	-	-	-	3	-	7	**10**
Scientific articles in peer-reviewed conference materials	3	-	-	-	-	8	-	6	**17**
Published industry research reports	-	-	-	-	-	-	4	5	**9**
Total scientific publications	9		-		51		38		
	9				89				**98**

I would like to mention that the list of scientific publications does not include the two previously mentioned paper, which I wrote with co-authors from foreign universities as part of the SIMBIO project. The first one was submitted to the Business Strategy and the Environment (IF 2023: 12.5) and received positive reviews. It is currently in the process of receiving final comments from reviewers and will soon be sent back to the editors. The second article was submitted to the Journal of Cleaner Production (IF 2023: 9.7). The editors submitted it for review.

I will add that also together with prof. Renato Passaro, Dr. Ivana Quinto (Parthenope University of Naples) and Marta Raźniewska, we also finish the previously mentioned scientific article entitled " Sustainable packaging introduction in a transatlantic supply chain – distributor perspective ", which is the result of my foreign fellowship at Parthenope University of Naples.

After obtaining my doctoral degree, my publications were cited 27 times in the Scopus database, 36 times in the Web of Science database and 256 times in the Google Scholar database (excluding self-citations). The Hirsch index is: for the Scopus database: 3, for the Web of Science database: 3 and for the Google Scholar database: 8 (Table 11).

In turn, the number of items indexed in individual databases is:

- Scopus: 7
- Web of Science: 8
- Google Scholar: 75

Table 11. Indicators of scientific achievements.

	Before obtaining PhD (until 2010)		*After obtaining PhD (od 2011 roku)*	
Number of citations	*Together*	*Without self-citations*	*Together*	*Without self-citations*
Scopus	-	-	27	27
Web of Science	-	-	38	36
Google Scholar	6	3	314	256
Indeks Hirscha	*Before obtaining PhD*		*After obtaining PhD*	
Scopus	-		3	
Web of Science	-		3	
Google Scholar	-		8	

Source: Library of the Faculty of Management of the University of Lodz, August 12, 2024

For my scientific work after obtaining my doctoral degree, I received 5 awards and distinctions:

- 2012: third-degree individual award of the Rector of the University of Lodz for the book entitled „Zarządzanie ryzykiem w łańcuchu dostaw na rynku B2B", Difin, Warszawa.
- 2014: first-degree team award of the Rector of the Poznań University of Economics for the book entitled „ Managing Towards Supply Chain Maturity Business Process Outsourcing and Offshoring", Palgrave Macmillan.
- 2015: award of the Foundation of the University of Lodz, for special scientific achievements in 2013-2014 in the area of social sciences in the group of young scientists of the University of Lodz.
- 2019: award for the best presentation at the conference „8th International Conference on Operations and Supply Chain Management (OSCM)", Cranfield University (Wielka Brytania).
- 2023: distinction for the highest-scoring publication in 2022-2023 at the Faculty of Management of the University of Lodz.

4.5.3.2. Participation in scientific conferences

I pay particular attention to the exchange of scientific knowledge with scientists from Poland and abroad during scientific conferences. Before obtaining my PhD degree, I participated in 4 national conferences. I presented papers, which were then published as peer-reviewed scientific publications (Table 10, Table 12).

After obtaining my PhD degree, I participated in 18 national and 16 international conferences. However, due to the often parallel research I conduct in various research teams and different possibilities of financing project trips (especially for foreign conferences), the research results of the team of which I was a member were additionally presented at 4 conferences in Poland and 11 abroad. Thanks to the conference activity, the results of research carried out independently or in cooperation were published in 33 scientific studies (including 12 written independently and 21 written in co-authorship).

Table 12. Numerical summary of participation in scientific conferences.

	Type of conference participation	National conference (in Polish)	International conference (in English)
Before obtaining PhD	Participation in a conference with presentation and publication	4	-
	Together	**4**	
After obtaining PhD	Participation in a conference with presentation and publication	7	14
	Participation in a conference with presentation	7	2
	Participation in the conference without presentation, with publication	4	-
	A conference during which the research results of the team I was a member of, were presented (with participation and publication)	-	3
	A conference during which the research results of the team I was a member of, were presented (with participation)	1	-
	A conference during which the research results of the team I was a member of, were presented (without participation and with publication)	1	4
	A conference during which the research results of the team I was a member of, were presented (without participation)	2	4
		22	**27**
	Together	**49**	

4.5.3.3. Projects activities

The implementation of scientific and research work is possible thanks to obtaining the necessary financing. Therefore, I systematically try to apply for it (Table 13, Table 14). Until obtaining a doctoral degree, the source of financing was participation in statutory research. In the period after obtaining my doctoral degree, I also implemented also projects under grants for young scientists as well as projects financed in domestic competitions and financed in foreign competitions.

Projects financed in domestic competitions received a grant from the National Science Center. The first project titled „Outsourcing and offshoring in supply chains: information and risk management and the level of supply chain maturity according to the Poirier model" (2011-2012), was headed by dr hab. Maciej Szymczak, prof. UEP. The project team also included: dr Anna Baraniecka (Wrocław University of Economics) and dr Mariusz Szuster (Poznań University of Economics). I received the second NCN grant on my own for the implementation of the project

entitled "Flexibility in relationships with suppliers in terms of supplier-purchaser models of cooperation on product development in the B2B market" (2017-2020). In the project, I acted as a manager and implemented all planned tasks.

Among the 9 projects financed through foreign competitions, there were 2 projects in which I acted as a manager at the University of Lodz, simultaneously implementing the tasks planned therein. The first international project titled „ELIEMENTAL: Breaking Down Barriers to Enterprise" (2012-2015), which I managed is an educational project with a research and application element. It was conducted as part of the program *Erasmus Life Long Learning*. The second international project I managed titled: "New Frontiers in Social Innovation Research: Social Innovation Management for BIOPlastics" (2020-2023) is a research and development project conducted as part of the program *Trans-Atlantic Platform Social Innovation*, in Poland financed by the National Center for Research and Development.

Table 13. Numerical summary of participation in projects financed in domestic and foreign competitions.

	One-person project in which I was the **project manager**	**Team** project, in which I was the **project manager**	**Team** project, in which I played a **role other** than project manager	**Together**
Projects financed through **national** competitions	1	-	1	2
Projects financed through **foreign** competitions	-	2	6	8
Total number of projects I implemented	1	2	7	10

In the remaining 6 international projects, I played a role other than project manager, i.e.:

- The role of a researcher in an international research project entitled „Promoting Circular Economy in the Food Supply Chain, ProCEeds", conducted under the program *Horizon 2020 EU's Marie Skłodowska-Curie Research and Innovation Staff Exchange* (2019-2023).
- The role of a consultant and expert in an international research project entitled „Food in Eco Network internationalization and global competitiveness of European SMEs in Food and Eco Logistics Sector, FOODNET", conducted under the program *COSME* oraz *Horizon 2020* (2018-2019).
- The role of a contractor in an international research and development project entitled "Promoting Environmentally Sustainable SMEs (PrESS)" (2013-2015), conducted under the program *Lifelong Learning Programme Centralized, Erasmus Multilateral Projects*;
- The role of a researcher in an international research and development project entitled „Functioning of the Local Production Systems in the Conditions of Economic Crisis (Comparative Analysis and Benchmarking for the EU and Beyond), FOLPSEC" (2012-2015); conducted under the program *"People" implementing the 7th Framework Programme of the European Community for research, technological development and demonstration activities*.

- The role of the contractor in an international educational project with a research element entitled "TrainERGY - Training for Energy Efficient Operations" (2015-2018), conducted under the program *Erasmus Life Long Learning Programme* (*Erasmus* +).
- The role of an evaluator of training materials in an international educational project with a research element entitled "ELIE Employability: Learning through International Entrepreneurship" (2010-2012), conducted under the program *Erasmus Life Long Learning Programme* (*Erasmus* +).

In addition to national and international projects, I carried out 14 research topics financed as part of research grants for young scientists or as part of the statutory activities of the Department of Logistics, Faculty of Management, University of Lodz (Table 14). Among the 6 research topics conducted as part of research grants for young scientists, in 3 topics I was an independent investigator of a research topic, in 2 topics I was the leader of a research team and once I was a researcher of a team topic. Additionally, in the years 2011-2018 I also participated in annual research conducted as part of the statutory activities of the Department of Logistics, Faculty of Management, University of Lodz.

Table 14. Numerical summary of participation in the implementation of annual research topics.

	Independent investigator of a research topic	Head of the research team	Team topic researcher	**Together**
Research grants for young scientists	3	2	1	6
Participation in research of the Department of Logistics, Faculty of Management, University of Lodz, carried out as part of its statutory activities	-	-	8	8
Total participation in the implementation of research topics	3	2	9	14

4.5.3.4. Supervising academic staff

After obtaining doctoral degree, I participated in the supervising of academic staff and acted as an assistant supervisor twice:

1.

The role of assistant supervisor for the implementation-oriented dissertation in the doctoral proceedings of mgr Rafał Rasztorf was entrusted to me by the Committee for Scientific Degrees in the Discipline of Management and Quality Sciences on January 18, 2019. The supervisor of the dissertation titled "Conditions for Building Partnership Relations with MRO Suppliers for Manufacturing Enterprises in Poland" was prof. dr hab. Maciej Urbaniak. My involvement concerned consultations on the development of the theoretical part of the dissertation, planning the methodology

and designing the questionnaire for the quantitative research, as well as preparing the implementation section.

The main goal of the dissertation: to identify areas of supplier relationship management requiring improvement and to propose a methodology for implementing best practices aimed at mitigating barriers to the development of partnerships between MRO suppliers and manufacturing companies in Poland.

On April 17, 2023, the following reviewers were appointed: dr hab. Łukasz Hadaś, prof. PP, dr hab. Aleksaner Lotko, prof. UTH w Radomiu, and dr hab. inż. Krzysztof Witkowski, prof. UZ.

The defense of the doctoral dissertation took place on October 23, 2023, and the degree of doctor of economic sciences was awarded on November 27, 2023.

2.

The role of assistant supervisor for the dissertation in the doctoral proceedings mgr Cao Son Nguyena, was entrusted to me by the Committee for Scientific Degrees in the Discipline of Management and Quality Sciences on May 24, 2021. The supervisor of the dissertation written in English language entitled „*Entry strategies of Polish enterprises into the Vietnamese market under the conditions of the European Union-Vietnam Free Trade Agreement (EVFTA)*" was prof. dr hab. Jan Jeżak. My involvement concerned consultations in the development of the theoretical part of the work, planning the methodology and preparing a questionnaire for the purpose of conducting a quantitative study, as well as the description and interpretation of the results of the quantitative study.

The main objective of the dissertation was to determine the existing entry strategies used by Polish enterprises when entering the Vietnamese market and the directions of the changes in these strategies under the conditions of the EU-Vietnam Free Trade Agreement (EVFTA), as well as to identify and analyze the determinants of the entry strategies of the Polish enterprises and, based on that, to indicate an effective path to enter this market.

On July 3, 2023, the following reviewers were appointed: prof. dr hab. Nelly Daszkiewicz, prof. dr hab. Krzysztof Wach oraz dr hab. Monika Chodorek, prof. Uniwersytetu WSB Merito.

The defense of the doctoral dissertation took place on December 18, 2023, and the degree of doctor of economic sciences was awarded on January 15, 2024.

4.5.3.5. Scientific reviews

After obtaining my doctoral degree, I performed a number of reviews of scientific articles for domestic and foreign magazines and for scientific conferences. Selected reviews are presented in Table 15 and Table 16. In addition to reviewing scientific articles for Polish and foreign journals, as well as part of national and international conferences, I prepared reviews of applications for research funding, performing the following functions:

- Function as an expert in the Sonata 26 competition of the National Science Center in the period: 19.10.2017-31.01.2018.

- Reviewer function within the funding " Excellence Initiative – Research University" University of Lodz, 2022.

Table 15. Numerical summary of reviews performed for domestic and foreign magazines.

No.	Journal title	Publisher	Year	Number of reviewed manuscripts
1	*Journal of Environmental Management*	Sciencedirect	2023	1
2	*Operations and Supply Chain Management: An International Journal*	Operations and Supply Chain Management Forum	2023	1
3	*Przemysł Spożywczy*	Wydawnictwo Czasopism i Książek Technicznych SIGMA-NOT	2023	1
4	*IEEE Engineering Management Review*	IEEE Technology and Engineering Management Society	2022	1
5	*Journal of Industrial and Production Engineering*	Taylor & Francis	2020	1
6	*Organizations and Markets in Emerging Economies*	Vilnius University Press Scholarly Journals	2020	2
7	*Enterprise Information Systems*	Taylor & Francis	2019	1
8	*IEEE Access*	Institute of Electrical and Electronics Engineers Inc.	2019	1
9	*International Journal of Intelligent Enterprise*	Inderscience Publishers	2019	1
10	*Logforum*	Wyższa Szkoła Logistyki w Poznaniu	2019	1
11	*International Journal of Integrated Supply Management*	Inderscience Publishers	2017	1
12	*Journal of Business and Economics*	Springer	2015	1
13	*International Journal of Supply Chain and Operations Resilience*	Inderscience Publishers	2015	1
14	*International Journal of Business Performance and Supply Chain Modelling*	Inderscience Publishers	2015	1
15	*International Journal of Business Excellence*	Inderscience Publishers	2015	1
	Together			**16**

Table 16. Numerical summary of reviews performed for domestic and foreign conferences.

No.	Conference title	Date, localization	Number of reviewed manuscripts
1	*Conference titled "Sustainable and Socially Responsible Development in the Network of Socioeconomic Relations", Uniwersytet WSB Merito w Gdańsku*	28.09.2023-30.09.2023, Gdańsk	1
2	*9th International Conference on Operations and Supply Chain Management (OSCM), RMIT University*	15.12.2019-18.12.2019, Ho Chi Minh, Vietnam	1
3	*I Conference SKN SCM, Faculty of Management UŁ*	09.04.2014-10.04.2014, Lodz	2
4	*Conference titled „Wpływ młodych naukowców na osiągnięcia polskiej nauki", V*	2014, Kraków	1

	edition, Kraków, The Krakow University of Economics		
	Together		**5**

5. Presentation of significant scientific activity carried out at more than one university, scientific institution, especially at foreign institutions

From the beginning of my scientific career, I have paid particular attention to building relationships and cooperation in the research, teaching and organizational fields with scientists from other universities in our country and abroad. I develop my scientific activity, also at the international level, in the following way:

- carrying out research fellowship abroad;
- participating in European programs in connection with the implementation of teaching mobility;
- participating in international research, R&D and educational projects, both as a manager and contractor;
- publishing in international journals;
- actively participating in international scientific conferences;
- preparing reviews of scientific articles for international journals and international scientific conferences.

5.1. Foreign research fellowships

In order to develop my scientific and research competences and striving to build relationships with scientists from abroad, I completed the following foreign research fellowships:

I.

Fellowship characteristics	Scientific
Hosting institution	Parthenope University of Naples, Naples, Italy
Implementation period	Stay I: 04.09.2022- 18.09.2022
	Stay II: 10.06.2023- 25.06.2023
Role	Researcher
The main goal of the fellowship	Carrying out research on sustainable development and circularity in international supply chains, as part of an international project „Promoting Circular Economy in the Food Supply Chain, ProCEeds", H2020-EU.1.3.-EXCELLENT SCIENCE-Marie Skłodowska-Curie Actions. The fellowship included the implementation of a project for the Italian company Agritalia, a distributor of food products on the American market, as well as cooperation with scientists from the University of Naples. The project aimed to support the company in identifying areas with the greatest potential for introducing circular economy principles (part I of the fellowship including stay I) and the selection of two key directions for improving the supply chain along with possible to implement circular solutions (part II of the fellowship including stay II).

2.

Fellowship characteristics	Scientific
Hosting institution	Ternopil National Economic University, Tarnopol, Ukraine
Implementation period	08.08.2014-21.08.2014
Role	Researcher
The main goal of the fellowship	Carrying out research on identifying and transferring best practices in the functioning and stimulating the development of local production systems, as part of an international project „FOLPSEC: Functioning of the Local Production Systems in the Conditions of Economic Crisis (Comparative Analysis and Benchmarking for the EU and Beyond)", in which the University of Lodz was a partner. Program "People" implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities, Agreement no. FP7 PEOPLE 2011 IRSES.

3.

Fellowship characteristics	Scientific
Hosting institution	Novosibirsk State University, Novosibirsk, Russia
Implementation period	06.09.2013-27.09.2013
Role	Researcher
The main goal of the fellowship	Carrying out research on identifying and transferring best practices in the functioning and stimulating the development of local production systems, as part of an international project „FOLPSEC: Functioning of the Local Production Systems in the Conditions of Economic Crisis (Comparative Analysis and Benchmarking for the EU and Beyond)", in which the University of Lodz was a partner. Program "People" implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities, Agreement no. FP7 PEOPLE 2011 IRSES.

The first stay and the second stay as part of an fellowship at the Parthenope University of Naples in Italy were financed as part of an international research project titled "Promoting Circular Economy in the Food Supply Chain, ProCEeds " (Programme: Horizon 2020 EU's Marie Skłodowska-Curie Research and Innovation Staff Exchange), in which the University of Lodz was one of the partners. The fellowship involved the implementation of a project for the Italian company Agritalia, a distributor of food products on the American market, as well as research and scientific cooperation with foreign scientists, such as prof. Renato Passaro (Parthenope University of Naples) and prof. Andrea Genovese (University of Sheffield, UK). The detailed goals and effects of the two parts of the fellowship (I and II) are presented in the description of the third research stream in point 4.5.2. ("Characteristics of scientific and research achievements after obtaining the degree of doctor of economic sciences in the field of management sciences").

The second fellowship and the third fellowship concerned cooperation with universities: Ternopil National Economic University in Ukraine and Novosibirsk State University in Russia. Both stays were financed as part of the international research project titled „ Functioning of the Local Production Systems in the Conditions of Economic Crisis (Comparative Analysis and Benchmarking for the EU and Beyond), FOLPSEC" (Program: "People" implementing the 7th Framework

Programme of the European Community for research, technological development and demonstration activities), in which the University of Lodz was one of the partners.

The detailed objectives and scientific research effects of the second fellowship and the third fellowship are presented in the description of the second research stream in point 4.5.2. („Characteristics of scientific and research achievements after obtaining the degree of doctor of economic sciences in the field of management sciences").

5.2. Teaching mobility to foreign institutions

In order to expand my scientific, research and teaching horizons, I also implemented teaching mobility as part of the European Erasmus+ program, financed by the European Commission. I completed four stays at foreign universities, giving lectures and workshops and presenting issues in the light of my own research results. During the mobilities, I also participated in scientific and research discussions with scientists from abroad (Table 17).

Table 17. Stays carried out as part of Erasmus + teaching mobility.

No.	Hosting institution	Mobility period	Characteristics of the stay:
1.	Kaunas University of Technology, Kowno, Lithuania	01.05.2015-09.05.2015	Conducting a lecture and workshops titled "Improvement of relationships with suppliers using risk management" (8 h)
2.	University of Aveiro, Aveiro, Portugal	05.05.2013-12.05.2013	Conducting a lecture and workshops titled "Ensuring safety of products in relationship with suppliers" (6h)
3.	Cantabria University Santander, Spain	22.04.2012-28.04.2012	Conducting a lecture titled "Supply chain risk management" (5h)
4.	Polytechnic Institute of Porto, Porto, Portugal	20.03.2011-26.03.2011	Conducting a lecture titled "Risk management in supplier-purchaser relations on the B2B market" (5h)

5.3. Cooperation with foreign institutions

My cooperation with foreign universities is developed primarily through my participation in international projects financed through foreign competitions (Table 13). So far, I have managed two such team projects:

1.

Project title	New Frontiers in Social Innovation Research: Social Innovation Management for BIOPlastics (SIMBIO)
Project characteristics	Research and development
Project type	International, team project
Program name	Trans-Atlantic Platform Social Innovation
Financing institution in Poland	The National Center for Research and Development (NCBR)
Project number	T-AP SI/SIMBIO/1/2020
Implementation period	01.09.2020-31.12.2023 (project completed)
Project budget (University of Lodz)	433 251,00 PLN
Role	Co-author of the application Main researcher, project manager at the University of Lodz Performer of planned tasks

Main project objective	Development of social innovations that meet environmental and social challenges in the use of bioplastic packaging in supply chains, taking into account the entire life cycle of these products
Project partners	Simon Fraser University, Burnaby, BC, Canada (Coordinator) Federal University of São Carlos, São Carlos, Brazil Coventry University, Coventry, Great Britain SGH Warsaw School of Economics, Warsaw, Poland University of Lodz, Poland
Project website	https://simbioresearch.com/

2.

Project title	ELIEMENTAL: Breaking Down Barriers to Enterprise
Project characteristics	Educational with a research component
Project type	International, team project
Program name	Erasmus Life Long Learning, EACEA - Education, Audiovisual and Culture Executive Agency, Leonardo da Vinci, Multilateral projects for developing of innovation
Project number	527949-LLP-1-2012-1-UK-LEONARDO-LMP
Implementation period	31.12.2012-30.12.2015 (project completed)
Project budget (University of Lodz)	37 523 €
Role	Project manager Contractor
Main project objective	Identify socio-cultural barriers to entrepreneurship, using a participatory action research (PAR) approach, and develop and test effective learning tools, supported by online mentoring systems, for developing and applying entrepreneurial skills
Project partners	University of Lancaster, Great Britain (Coordinator) Tameside College, Great Britain ERGANI Center For The Support Of The Employment And Entrepreneurship, Greece Minority Ethnic Network Eastern Region, Great Britain The Business Group Salford, Great Britain The South-East European Research Centre (SEERC), Greece Valahia University of Târgoviște, Romania University of Lodz, Faculty of Management, Poland

The implementation of the above projects was a source of extensive experience for me in substantive management of international projects, building research and scientific relationships in international teams, as well as planning and settling projects, taking into account the importance of reporting and project administration. Cooperation with foreign partners broadened my scientific horizons and enriched my research skills with the mature approaches in designing the research process. Moreover, the socio-environmental dimension of the issues of both projects developed my knowledge and skills in the field of managing sustainable supply chains and managing chains in a circular economy. I currently use the acquired social competences (including team management and motivation, effective communication in conditions of cultural diversity) and many years of experience (both projects were three-year projects) in carrying out further scientific and research work at the international level.

The quantifiable results of both projects include scientific articles (8, including 1 with partners from Canada, Brazil and the UK, which was submitted to the journal Business Strategy and the Environment, and received positive reviews, and 1 with partners from the UK, which is currently

under review in the Journal of Cleaner Production), papers and posters at national and international conferences (14), industry reports (9), activities in the field of design and prototyping of 4 solutions stimulating the development of the compostable packaging market. I presented a detailed description of the assumptions and international scientific and research effects (with my participation) in the description of the second research stream in point 4.5.2. („Characteristics of scientific and research achievements after obtaining the degree of doctor of economic sciences in the field of management sciences") and point 4.5.3.3. ("Projects activities").

I participated in the remaining six international projects in a role other than manager:

1.

Project title	TrainERGY - Training for Energy Efficient Operations
Project characteristics	Educational with a research component
Project type	International, team project
Program name	Erasmus Life Long Learning Programme (Erasmus +)
Project number	2015-1-PL01-KA203-016919
Implementation period	01.09.2015-31.08.2018 (project completed)
Project budget (University of Lodz)	65 445 €
Role	Contractor
Main project objective	Developing innovative solutions that will increase knowledge and skills in the field of energy efficiency and sustainable development
Project partners	University of Sheffield, Great Britain (Coordinator) Olympia Electronics, Poland FALP s.r.l., Neapol, Italy Fundacja Rozwoju Przedsiębiorczości, Poland Parthenope University of Naples, Italy The South-East European Research Centre (SEERC), Greece University of Lodz, Faculty of Management, Poland
Project website	https://www.trainergy-project.eu/language/en/

2.

Project title	Promoting Circular Economy in the Food Supply Chain, ProCEeds
Project characteristics	Research project
Project type	International
Program name	Horizon 2020 EU's Marie Skłodowska-Curie Research and Innovation Staff Exchange
Project number	823967
Implementation period	01.09.2019-31.12.2023 (project completed)
Project budget (University of Lodz)	36 800 €
Role	Researcher
Main project objective	Examining circular economy paradigms implemented at various system levels of the studied regions and assessing the level of their system integration. Assessment of environmental costs and benefits resulting from the use of innovative models in the agri-food industry. Identify and assess different categories of drivers and barriers faced by organizations in implementing circular economy principles. Assessment of whether and to what extent it is possible to implement a circular economy in agri-food.
Project partners	The University of Sheffield, Great Britain (Coordinator) The South-East European Research Centre (SEERC), Greece Universitá Degli Studi Di Napoli Parthenope, Italy Regather Co-Operative, Great Britain Proteg SpA, Italy Solagri Soc. Coop., Italy Nefeloudis, Greece

	Instituto Nacional De Tecnologia Agropecuaria, Argentina Fundacja Rozwoju Przedsiębiorczości w Łodzi, Poland University of Lodz, Poland
Project website	http://proceeds-rise.eu/

3.

Project title	Food in Eco Network internationalization and global competitiveness of European SMEs in Food and Eco Logistics Sector, FOODNET
Project characteristics	Research project
Project type	International, team project
Program name	COSME (program ramowy na rzecz konkurencyjności przedsiębiorstw oraz małych i średnich przedsiębiorstw) oraz Horizon 2020
Implementation period	16.12.2017-16.12.2019 (project completed)
Role	Consultant and expert within the tasks carried out in the project, during the period 22.01.2018-15.06.2019
Main project objectives	1. Increasing the potential of European food market clusters by improving business and logistics processes towards sustainable development. 2. Creation of the Food In Eco Network (FoodNet), a European meta-cluster, a strategic partnership in the European Union.
Project partners	LODZistics Logistics Business Network of Central Poland (Poland) Logistics in Wallonia (Belgium) Latvian Logistics Association (Latvia) AgroTransilvania Cluster (Romania) Coexphal Association of Fruit and Vegetable Producer Organisations of Almeria (Spain)

4.

Project title	Promoting Environmentally Sustainable SMEs (PrESS)
Project characteristics	Research and development project
Project type	International, team project
Program name	Lifelong Learning Programme Centralized, Erasmus Multilateral Projects
Project number	538851-LLP-1-2013-1-UK-ERASMUS-EQR
Implementation period	01.10.2013-30.09.2015 (project completed)
Project budget (University of Lodz)	48 283 €
Role	Contractor
Main project objective	Identification and assessment of the scope of application of the so-called Green Practices in the area of sustainable development by small and medium-sized enterprises.
Project partners	University of Sheffield, Management School, Great Britain The South-East European Research Centre (SEERC), Greece University of Naples "Federico II", Department of Industrial Engineering, Włochy Association of Information Technology Companies of Northern Greece, Greece Sheffield Chamber of Commerce and Industry, Great Britain University of Lodz, Faculty of Management, Poland

5.

Project title	Functioning of the Local Production Systems in the Conditions of Economic Crisis (Comparative Analysis and Benchmarking for the EU and Beyond), FOLPSEC
Project characteristics	Research project
Project type	International project
Program name	"People" implementing the 7th Framework Programme of the European Community for research, technological development and demonstration

	activities. MC-IRSES - International research staff exchange scheme (IRSES)
Agreement number	FP7 PEOPLE 2011 IRSES
Implementation period	01.04.2012-31.03.2015 (project completed)
Role	Researcher
Main project objectives	1. Exchange of knowledge on research approaches in the study of local production systems (LPS) and formulation of recommendations regarding the implementation of good EU practices in conditions of economic crisis 2. Sharing results regarding the functioning of LPS in terms of regional economic and social acceleration and overcoming regional disparities 3. Implementation of the acquired knowledge and good practices in research and teaching in all partner institutions 4. Establishing long-term research cooperation between the EU and third countries and strengthening research partnerships.
Project partners	University of National and World Economy, Sofia, Bulgaria (Coordinator) Univerzita Mateja Bela v Banskej Bystrici, Banska Bystrica, Slovakia Ternopil National Economic University, Ukraine Novosibirsk State University, Russian Federation University of Lodz, Poland

6.

Project title	ELIE Employability: Learning through International Entrepreneurship
Project characteristics	Educational with a research component
Project type	International, team project
Program name	Erasmus Life Long Learning Programme (Erasmus +)
Project number	510778-LLP-1-2010-1-UK-ERASMUS-ECUE
Implementation period	18.06.2010-06.07.2012 (project completed)
Project budget (University of Lodz)	49 961 €
Role	Evaluator of training materials (WP 8: Evaluation and Quality Assurance)
Main project objective	Developing new methods of providing skills to start their own business if they emigrate from their country of birth
Project partners	Ardin Software, Finland University of Salford, Great Britain University of Turku, Finland Chapel Street Business Group, Great Britain South East European Research Centre (SEERC), Greece Thessaloniki Chamber of Commerce and Industry, Greece University of Lodz, Faculty of Management, Poland

Participation in teams of six international projects as a contractor, researcher or evaluator was a source of enormous research and scientific experience for me, but from a slightly different perspective, as a member of the teams. During my work, I participated in meetings at the international level, built relationships with foreign scientists, conducted discussions on research processes and prepared research and scientific publications. W As part of two international projects, I completed three foreign research internships, which were particularly important to me from the point of view of my scientific and research development and international cooperation. One of them (collaboration with scientists from Parthenope University of Naples), despite the formal end of the project implementation period, is still continued, i.e. we conducted next (quantitative, CATI) study on global product development chains of sustainable food packaging, the results of which we will present in joint papers.

The measurable results of the six projects mentioned include (with my contribution) scientific publications (9, including 5 with foreign partners) and papers at domestic and foreign conferences (9, including 6 in co-authorship with foreign authors). I presented a detailed description of the assumptions and international scientific and research effects (with my participation) in the description of the second and third research stream in point 4.5.2. („Characteristics of scientific and research achievements after obtaining the degree of doctor of economic sciences in the field of management sciences") and point 4.5.3.3. ("Projects activities").

6. Presentation of teaching and organizational achievements as well as achievements in popularization of science

6.1. Characteristics of teaching activities

My teaching activities in the period 2007-2024 include conducting classes, lectures, and seminars in the first and second cycle of fields such as: Logistics, Logistics in business, Digitization and data management in business, Automation of business processes.

As part of the above-mentioned study programs, full-time and part-time, I completed the following courses in Polish:

- Audit of logistics processes;
- Logistics audit;
- Security and continuity of processes in the supply chain;
- Improving processes and products;
- Logistics infrastructure;
- Supply chain resilience;
- Standardization and quality management in logistics;
- Standardization according to ISO EN and PN;
- Basics of logistics;
- Basics of logistics process management;
- Business continuity management standards;
- Standardization of processes and products;
- Standardization in company management;
- Commodity science;
- Security management in the supply chain;
- Supply chain management;
- Logistics project management;
- Risk management;
- Risk management in logistics processes;
- Environmental management - ISO-14001 standard;

- Environmental and occupational safety management;
- Integrated management systems;
- Logistics audit.

As part of the study programs in the following fields: Management, Management and Marketing, full-time, I also completed the following courses in English:

- *Business Excellence*;
- *Standardization Conform to ISO, EN and PN.*

In addition, I conducted courses in English in the following subjects for foreign students performing student mobility under the European Erasmus+ program at the Faculty of Management of the University of Lodz:

- Excellence Management Tools;
- Integrated and Sector Management Systems;
- Standardization of Processes and Products.

I also shared my knowledge and experience with students of the following postgraduate studies:

- Postgraduate studies „Logistics process management" (since 2012/2013 to 2017/2018), lecture: Risk in logistics.
- Postgraduate studies conducted by the Department of Quality Management, Faculty of Management, University of Lodz (2011-2014), lectures: Quality in logistics systems, Improving relationships with clients and suppliers in the supply chain.
- Postgraduate studies in Social University of Entrepreneurship and Management in Łódź, lecture: *Proces and Quality Management* (2010).

After obtaining a doctoral degree, I started conducting bachelor's and master's seminars for full-time and part-time studies. The number of theses that I supervised with a positive result in the diploma examination (in the period July 2011 - July 2024) is 226, including 125 for master's seminars and 101 for bachelor's seminars (Table 18).

Table 18. Teaching activities - the function of supervisor and reviewer of diploma theses.

Number of promoted master's theses	125
Number of promoted bachelor's theses	101
Together	**226**
Number of reviewed master's theses	152
Number of reviewed bachelor's theses	123
Together	**275**

Source: Archive of Diploma Theses of the University of Lodz

During this period, I was also a reviewer of bachelor's and master's theses for full-time and part-time studies. In total, I reviewed 275 diploma theses, including 152 master's theses and 123 bachelor's theses.

I was also the coordinator for original courses for Logistics in Business program. The content for these courses, which I have improved annually, has been highly rated by students for many years[36]:

- Supply chain management (Logistics in business program), from 2016 - until now.
- Supply chain resilience (Logistics in business program), from 2020 roku - until now;
- Safety management in the supply chain (Logistics in business program), from 2013 - until now 2019.

I also served as an assistant supervisor in two finished doctoral proceedings:

- „Conditions for Building Partnership Relations with MRO Suppliers for Manufacturing Enterprises in Poland" (implementation-oriented dissertation), and
- "Entry strategies of Polish enterprises into the Vietnamese market under the conditions of the European Union-Vietnam Free Trade Agreement (EVFTA)" (dissertation written in English).

6.2. Characteristics of organizational activities

I am also actively involved in the organizational work of the Faculty of Management of the University of Lodz. Since obtaining my doctoral degree, I have performed various functions and carried out various activities:

- in 2011, I participated in the development of the program concept regarding new fields of study and specializations at the Faculty of Management of the University of Lodz and the proposed educational outcomes;
- In 2011, I took part in the development of an innovative educational program in the field of Logistics at the Faculty of Management;
- in the years 2012-2016 I served as a member of the Committee for the Quality of Education at the Faculty of Management of the University of Lodz;
- since 2012, I have been a member of the Program Council (as a coordinator) of first-cycle studies in Logistics at the Faculty of Management of the University of Lodz;
- in 2022, I acted as a reviewer under the "Excellence Initiative - Research University" program of the University of Lodz.

In 2011 and 2012, I received Dean's *awards* due to outstanding contributions to the Faculty of Management of the University of Lodz.

[36] The grades for my classes are available in the University of Lodz's internal system - Survey results.

Additionally, before obtaining a doctoral degree:

- I served as secretary of the Recruitment Committee of the Faculty of Management at the University of Lodz (2008/2009)
- I was a supervisor of student groups in the field of Logistics;
- I conducted training for students of the Faculty of Management in the field of occupational health and safety, in Polish and English.

I consider one of the most important organizational activities to be the internship supervisor at the Logistics Faculty of the Faculty of Management at the University of Lodz since 2013/2014. The number of students under my supervision since then has been over 1,000 [37]. As part of this function, I establish contacts and build relationships with various companies, both from the TSL industry, as well as production and distribution companies. I also support students in finding places for internships, both in our country and abroad. Internships at the Faculty of Management initially lasted 1 month, then 3 months, and for several years they have lasted 6 months, during which the intern is obliged to demonstrate 720 hours of practice.

My organizational achievements also include co-organization of scientific events, including:

- Scientific seminar „Opakowania kompostowalne – innowacje dla potrzeb rozwoju rynku opakowań do żywności", Warsaw School of Economics and University of Lodz, Warsaw, 23.09.2022.
- Scientific seminar Kolegium Nauk o Przedsiębiorstwie SGH oraz Wydziału Zarządzania UŁ pt.: „Determinanty rozwoju rynku bioopakowań w gospodarce o obiegu zamkniętym", 18.06.2021.

For many years, I have also been gaining skills in managing research teams::

- in international projects that received financing in foreign competitions: „New Frontiers in Social Innovation Research: Social Innovation Management for BIOPlastics (SIMBIO)" (2020-2023) and „ELIEMENTAL: Breaking Down Barriers to Enterprise" (2012-2015).
- as well as twice serving as head of a research team under research grants for young scientists. Research topics: "Improving processes in the supply chain" (2011) and "Supplier relationship management" (2012).

6.3. Characteristics of activities popularizing science

My activities popularizing science are mainly manifested in the publication of scientific and research works (Table 10) and active participation in conferences integrating academics and business practitioners (Table 12).

[37] The information is available in the University of Lodz's internal system - "Praktyki" Protocols.

By participating in international projects, I also carry out additional activities to popularize science. One of the most important examples is the activity in the international research and development project entitled „New Frontiers in Social Innovation Research: Social Innovation Management for BIOPlastics (SIMBIO)" (2020-2023). During the project, I co-organized three discussion panels (integrating the private sector, the public sector and the non-profit sector), the subject of which was the development of the bio-based food packaging market (including compostable packaging). As part of the project, I was also a co-author of 9 reports presenting research results, including 4 in Polish and 5 in English. Moreover, I was also responsible for planning and organizing activities at the University of Lodz in the field of dissemination of research results throughout the three years of the project. I also gave an interview on Radio Lodz about the conditions and development of the compostable packaging market in our country (24.05.2023).

I consider one of my significant achievements to be the inter-faculty initiatives I started at the University of Lodz in 2023, which culminated in May 2024 with the University of Lodz being appointed as a member of Technical Committee No. 133 for Packaging by the Polish Committee for Standardization. During the Committee's standardization work, I serve as the University of Lodz representative with voting right.

Additionally, in December 2023, as one of the representatives of the Faculty of Management at the University of Łódź, I initiated discussions with the Irish company Keelvar Systems Limited, which offers SaaS-based solutions for optimizing and automating procurement and supply chains.. The partnerships built with the company resulted in the involvement of students of the "Logistics in Business" field in three certified courses on supply/purchase optimization (completed with exams) and in the implementation of tenders using an advanced purchasing platform based on real data. The University of Lodz is the only Polish university, out of several universities from around the world, involved in cooperation in the Keelvar academic program (https://www.facebook.com/Wydzial.Zarzadzania.UL/posts/975374097924201/). Positive feedback, both from the company and students after our first edition, resulted in the continuation and development of our cooperation for the coming years.

As part of its science popularization activities, I also undertook other activities, including:

- in the years 2019-2023, I acted as assistant supervisor in an implementation-oriented doctoral thesis;
- in 2021, I conducted an expert session entitled "Q&A Session with a supply chain" for DEKRA Group from Wrocław;
- w in 2018, I took part in the review process of the occupational information project: Purchasing Department Manager 132403 as part of the project: Developing, supplementing and updating information about professions and its dissemination using modern communication tools - INFODORADCA+, implemented by Intytut Analiz Rynku Pracy;

- as an employee of the Department of Logistics, Faculty of Management, University of Lodz, I cooperate with the Lodz cluster LODZistics Logistics Business Network of Central Poland. In 2018-2019, I was involved in the implementation of the joint project entitled: "Food in Eco Network internationalization and global competitiveness of European SMEs in Food and Eco Logistics Sector, FOODNET";
- In 2015, I co-led an expert lecture entitled "Supply chain management" for Infosys Poland in Łódź;
- In the period December 2011 - July 2012, I conducted training in "Management by Results (ZPR)" according to the MSI methodology, at the District Office in Łódź and the City Hall in Zgierz, as part of the project entitled „Przeprowadzenie wdrożenia Zarządzania przez Rezultaty (ZPR) lub tożsamej metodologii w wybranych Jednostkach Samorządu Terytorialnego", co-financed by the European Union under the European Social Fund (as a consultant of Umbrella Consulting Sp. z o. o.).

Grażyna Kędzia

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(podpis wnioskodawcy)