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Collaborative Implementation Of Product-Service Systems In Business Ecosystems – Empirical Investigation Of Neutral Third Parties As A Success Factor

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Abstract

The collaborative implementation of product-service systems is a promising field of action for the German mechanical engineering industry. Through the interaction in business ecosystems, mechanical engineering companies integrate complementary competencies and technologies from different actors into customer-centric solutions, which satisfy customer needs to a greater extent. However, collaborative initiatives in business ecosystems often fail in operation or are not implemented at all. The main cause is a lack of cooperation capabilities among the cooperation partners. To solve this issue, this paper investigates how cooperation capabilities can be increased efficiently by interacting with neutral third parties in business ecosystems. Neutral third parties contribute to forming and preserving collaborative initiatives in business ecosystems and reduce transaction costs through their impartiality and specific domain knowledge. Even though the neutral third-party approach is discussed in theory, it has yet been poorly examined in practice. To develop a better understanding regarding the practical fields of application and the requirements for the implementation of the neutral third party approach in the context of mechanical engineering business ecosystems, 29 expert interviews have been conducted. The findings contribute to the transfer of the neutral third-party approach into practice and thus increase the success of a collaborative implementation of product-service systems in business ecosystems.

Keywords

Business Administration; Digitalization / Industry 4.0; Business Ecosystem; Product-Service System

1. Introduction

The collaborative implementation of product-service systems (PSS) is a promising field of action for the German mechanical engineering industry, to enable growth in saturated markets and differentiation in global competition [1]. Through the interaction in business ecosystems, mechanical engineering companies integrate complementary competences and technologies from different actors into customer-centric solutions, which satisfy customer needs to a higher extent [2]. In addition, pooling resources in business ecosystems shares development risks and shortens time-to-market [3].

However, collaborative initiatives in business ecosystems often fail or are not implemented at all [3,4]. This phenomenon originates from conflicts that find their cause in the high technological and relational complexity as well as in extensive transaction costs of these collaborative initiatives [5–7]. The companies involved lack cooperation capabilities to efficiently manage these challenges in the phases of initiation, formation and operation [3,4,8]. Further, companies often do not recognize the missing cooperation capabilities or cannot develop them in a suitable time and cost frame [3,5].

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To solve this issue, this paper investigates how cooperation capabilities can be increased efficiently by interacting with neutral third parties in business ecosystems. This approach is based on the synthesis of the work of LUSH/NAMBISAN (2015) and DE JONG ET AL. (2013) Accordingly, neutral third parties contribute to forming and preserving collaborative initiatives in business ecosystems and reduce transaction costs through their impartiality and specific domain knowledge. [9,10] Although the neutral third-party approach is discussed in theory, it has yet been poorly examined in practice [9]. So far, in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems, practical fields of application and requirements for implementing the neutral third-party approach are unclear [9,11]. To close the described research gaps and thus contribute to the transfer of the approach into practice, expert interviews are conducted, including both qualitative interview techniques and quantitative ratings. Guiding the research process, the following research questions (RQ) are formulated.

RQ1: What are the fields of application for the neutral third-party approach in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems?

RQ2: Which requirements must be considered when implementing the neutral third-party approach in the collaborative implementation of PSS in mechanical engineering business ecosystems?

The second chapter of this paper provides a brief overview of the theoretical foundations of the collaborative implementation of PSS in mechanical engineering business ecosystems, cooperation capabilities, and interaction with neutral third parties. In the third chapter, the research method is explained and justified. The findings of the expert interviews are presented and discussed in the fourth chapter. In the last chapter, a conclusion is drawn concerning the research objective, and finally, a research outlook is given.

2. Theoretical foundations

2.1 Collaborative implementation of PSS

For German mechanical engineering companies, innovations are a key success factor to succeed in global competition [8]. Driven by the penetration of ICT in industry, implementing PSS represent a promising field of action to satisfy customer needs to a greater extent while significantly reducing imitability by competitors [3,12]. A PSS is considered a marketable combination of industrial products and services consisting of intelligent connected physical and digital components [13,14].

As innovation cycles become shorter and the competence requirements increase, a collaborative approach in business ecosystems that enables the integration of complementary competencies and technologies from different actors across industries becomes more and more necessary [8,15]. Business ecosystems are defined as networks consisting of different actors that must collaboratively interact to realize a value proposition in the customer's value chain [15]. In this context, modular combination and pooling are suitable approaches for integrating complementary competencies [16]. At the same time, cooperation forms with a more consensual coordination mechanism and a rather hierarchical coordination mechanism (e.g., by a focal company) are suitable for the collaborative implementation of PSS [15,17]. Government or public sector funding initiatives are not considered.

2.2 Cooperation capabilities

Although the discussion of cooperation capabilities has been rooted in the management and marketing literature since the late 1980s, a wide variety of concepts has emerged to describe the phenomenon of cooperation capabilities. Only KOHTAMÄKI ET AL. integrated the different approaches into one single concept. Accordingly, cooperation capabilities are to be considered in two forms. (1) As strategic or operational capabilities for coordination, structuring, strengthening ties, and learning in cooperations. (2) As a capability for reconfiguring the resources needed to meet cooperation objectives and sensing the need for

adaptation. The construct cooperation capabilities constitutes in processes and the competencies required for them. [11] This contribution follows the conceptualization of SCHMITT ET AL. (2022), which extends the previous work of KOHTAMÄKI ET AL. (2017) as described above by considering cooperation capabilities in the cooperation phases of initiation, formation, and operation [18].

Previous studies on cooperation capabilities are primarily empirical-quantitative, so that evidence is available, especially for antecedents (environmental, organizational, and relational conditions) for cooperation capabilities and their effect on cooperation performance [11]. Regarding the effect on cooperation performance, the literature states that there is a positive correlation between cooperation capabilities and collaboration quality as well as cooperation performance [19]. The processes and competencies constituting cooperation capabilities have been receiving less attention in research so far [5,11]. Furthermore, contextual information, such as the objective and framework conditions of cooperations, are rarely taken into account, even though they have a significant impact on collaboration and, thus, on the cooperation capabilities needed [11]. In this context, previous systematic literature reviews on collaborative implementation of PSS in business ecosystems fall short, as the underlying literature only considers segments of the research scope, and priorities regarding cooperation capability needs remain unclear [17,18].

2.3 Interaction with neutral third parties

According to LUSH/NAMBISAN (2015) and DE JONG ET AL. (2013), the cooperation capabilities of partners in business ecosystems can be increased by interacting with neutral third parties. In this context, neutral third parties contribute to forming and preserving collaborative initiatives in business ecosystems and reduce transaction costs through their impartiality and specific domain knowledge. [9,10] The interaction with neutral third parties is considered a service transaction in a market relationship [9,18]. Neutral third parties are characterized as follows. Neutral third parties (1) are not engaged in relationships with cooperation partners that could compromise impartiality, (2) serve the consensual cooperation objectives and should therefore be selected and compensated by all cooperation partners, and (3) have a sufficient reputation as a trusted authority [9].

In the context of collaborative innovation, the roles of neutral third parties have so far only been discussed in theory, leaving the practical fields of application unclear [9,20]. The review of previous literature shows that neutral third parties can influence the initiation and application of structural and relational governance mechanisms and support collaborative innovation activities [9,20,21]. However, it is not understood which actor in the business ecosystem can take on the respective role of the neutral third party and how they fulfill this role [9]. Further, the literature mentions actors only by example (e.g., research institution, industry association, consultancy), without referring to suitable roles [22]. So far, requirements for implementing the neutral third-party approach have only been derived from theory; practical suitability has not yet been studied [18].

3. Research method

To answer research questions RQ1 and RQ2, we chose expert interviews as appropriate research approach, as only fragmented information is available in the literature in the context of collaborative implementation of PSS in mechanical engineering business ecosystems [18]. With the aim of understanding the practical fields of application and requirements for the implementation of the neutral third party approach in the broad scope of consideration, 29 experts from companies of different sizes, industry segments and with varying levels of experience regarding the collaborative implementation of PSS were interviewed in Q3/2022 (Table 1). We interviewed C-level executives, directors in R&D, product management (PM) and business development (BD) as well as project managers with experience in the study context. With a population size of more than 5000 and a confidence level of 90%, the sample size of 29 yields a confidence interval of 85%.

Table 1: Sample composition

Size		Industry Segment		Experience Level*		Role	n=29
<100	7	Plant & Machinery	12	Low	9	C-Level Executive	8
<1000	5	Component Supplier	9	Medium	13	Director R&D	5
<10000	12	Part Supplier	1	High	7	Director PM/BD	10
>10000	5	ICT	7			Project Manager	6

*experience level is based on past and current activities of the company in the context of investigation

For the interviews, we used a semi-structured interview guideline, incorporating both qualitative interview techniques and quantitative ratings. A total of 1287 minutes of interview material was recorded and transcribed. To answer RQ1, interview participants were first asked about the main challenges of collaborative implementation of PSS. Building on these results, fields of application of the neutral third-party approach were explored in terms of addressing the previously identified challenges. In line with the conceptualization of cooperation capabilities, processes underlying the challenges of collaborative implementation of PSS, their relevance, and fields of application of the neutral third-party approach were synthesized through qualitative content analysis based on MAYRING ET AL. (2014) [23]. In addition, a quantitative rating was conducted to rank industry demand for the neutral third-party approach. To answer RQ2, the practical application of the neutral third-party approach was discussed with the experts. Through qualitative content analysis, practical application challenges were identified and consolidated into fields of action. Building on these results, requirements for the practical implementation of the neutral third-party approach were derived.

4. Findings and discussion

4.1 Fields of application for the neutral third-party approach in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems

This chapter examines the practical challenges associated with the collaborative implementation of PSS in mechanical engineering business ecosystems. Building on this, we explore how these challenges can be overcome through interaction with neutral third parties. The practical challenges of collaborative implementation of PSS in business ecosystems and their relative importance are explained using the results of the quantitative study presented in Table 2. In the phases of initiation, formation, and operation, 16 processes were identified that underlie the challenges mentioned by the experts. The results show that challenges are most frequently mentioned in the initiation phase (86%). More than half of the participants state challenges in the formation and operation phases. The processes identified and the associated challenges are presented in detail below.

Table 2: Challenges of collaborative implementation of product-service systems in business ecosystems

	Relative frequency of stating challenges in reference to the phase						n=29
	A Initiation	**86%**	**B Formation**	**62%**	**C Operation**	**55%**
Relative frequency of stating challenges in reference to the process	A1 Vision Creation & Follow-up	59%	B1 Legal & Tech. Configuration	45%	C1 Operating Model Design	34%
	A2 Structuring Value Creation	52%	B2 Common Understanding	34%	C2 Stakeholder Management	31%
	A3 Partner Persuasion	38%	B3 Negotiation	21%	C3 Conflict Management	24%
	A4 Partner Search & Selection	24%	B4 Implementation Planning	17%	C4 Coordination	21%
					C5 Adaption Of Configuration	10%
					C6 Sensing Need For Adaption	7%
					C7 Set Up Collaboration Platform	3%

(A1) Creating a vision for a customer-centric solution that satisfies customer needs to a greater extent is the biggest obstacle to the initiation of collaboration in mechanical engineering ecosystems. When generating

ideas, companies tend to think predominantly in terms of the competence areas of their own products or services rather than thinking outside the box putting customer value at the core. Consequently, only subsystems are targeted; holistic optimization of the customer's value creation processes is not achieved. In addition, companies lack the financial and human resources, as well as the risk appetite, to follow up on and launch these visionary initiatives beyond their competence area. (A3) The same challenges arise when convincing partners to participate in collaborative initiatives. (A2) Structuring value creation based on competency needs, market access, and incentivization is the key challenge in building viable business ecosystems. In this context, companies cannot develop an appropriate competency-building strategy (make, buy or collaborate) or position themselves because technology maturity levels and competence providers are often non-transparent, or opportunities and risks in the dynamic competitive environment cannot be anticipated adequately. However, most companies have a mindset problem. They prefer to implement solutions on their own or acquire and show little willingness to compromise when it comes to cooperation. (A4) The acquisition of information for identifying and evaluating potential partners is associated with high transaction costs. At the same time, evaluating the competencies of potential partners is difficult due to a lack of domain knowledge within the company's own organization – especially when it comes to ICT. For this reason, the mechanical engineering industry often works only with partners with a relationship of trust based on a shared history.

(B1) Insufficient understanding of legal frameworks and technical architectures that address the risk profile of the initiative, the appropriate handling of IP, and the flexibility requirements (due to the multiple commercialization opportunities of the company's contributions) inhibit the establishment of collaborations in the formation phase. This uncertainty about how to collaborate also means that potential partners cannot be convinced or that individual companies do not launch collaboration initiatives in the first place. (B2) Another challenge is to create a common understanding of the individual ambitions of the partners, the intended role, the associated benefits, and the common cooperation goal to ensure a win-win situation, especially when partners do not already know each other from previous relationships. This task is sometimes neglected, which leads to false expectations and, thus, conflicts. (B3) In addition, some collaborations do not materialize because the cost and duration of reaching a consensus is too high, or trust is lost during the negotiation of partner contributions and benefits. (B4) Due to the rather loose connections in business ecosystems and the associated lack of clear responsibilities or insufficient resources, the implementation planning is sometimes neglected, resulting in inefficiencies in the operational phase. Also, implementation cost and duration are underestimated. These misjudgments result from a lack of experience concerning the effort involved in the collaborative implementation of PSS.

(C1) In some cases, the cooperation partners do not manage to design an efficient and effective operating model that suitably connects to the core organizations of the partners, so high transaction costs arise and time to market is compromised. (C2) At the same time, stakeholders are not sufficiently informed and involved, resulting in dropping employee motivation as well as low management support and insufficient resource allocation. In addition, conflicts sometimes arise due to different cultural approaches and quality perceptions, especially when the quality of the partners' contributions cannot be adequately assessed due to a lack of domain expertise. (C3) Critical situations arise not only in this context, but also when there is no structure for addressing and resolving conflicts. (C4) The collaborative development and implementation of the customer-centric solution is often not systematic, resulting in waste and slow overall progress. The cooperation partners lack the necessary methodological competence to synchronize the technical and business perspectives as well as the different technological domains. Similar to implementation planning, coordination activities are sometimes neglected due to the rather loose ties in business ecosystems. (C5) Without the continuous adaptation of the cooperation framework to new goals and customer solutions as well as changing partner configurations, conflicts arise as the relationship between partner-individual benefits and contributions gets out of balance. (C6) In addition, recognizing the need for reconfiguration in the dynamic, collaborative environment is challenging due to limited monitoring resources. (C7) Only one

of the experts states that the absence of a collaboration platform where partners can share their proprietary tools, technologies, and other resources increases redundancies and slows down development.

In summary, challenges arise throughout all phases—initiation, formation, and operation. Consequently, all phases need to be studied in terms of the applicability of the neutral third-party approach. In line with the findings of the cross-industry studies by LINGENS ET AL. (2022) and PIDUN ET AL. (2020), the most significant challenges for successfully implementing collaborative initiatives in business ecosystems concern the initiation and formation phases [4,24]. Today, most collaborative initiatives in business ecosystems do not establish at all. If the operation phase is reached, collaborative initiatives in business ecosystems are more resilient. Difficulties in the operation phase are rather the slow implementation speeds and high transaction costs for coordinating collaboration.

Building on the processes identified, fields of application for the neutral third-party approach contributing to overcoming the challenges associated with the processes are presented in the form of roles of neutral third parties. Table 3 provides an overview of the roles identified in the expert interviews.

Table 3: Roles of neutral third parties in the context of the collaborative implementation of product-service systems in business ecosystems

Phase	**A Initiation**		**B Formation**		**C Operation**	n=29
Role	Visionary	A1-A4	Facilitator	B1-B3	Cooperation Mgmt. Support	C1-C4
	Sparring Partner	A1-A4	Benefit Assessor	B2	Orchestrator	C1-C4
	Technology Expert	A2, A4			Mediator	C3
	Ecosystem Maker	A2				
		Processes (Challenges) Adressed				

In the initiation phase, the **visionary** takes the initiative to create a vision for a customer-centric solution that satisfies customer needs to a greater extent, identifies suitable cooperation partners, and convinces the respective management of the initiative. In this way, the visionary undertakes the creation of a vision that goes beyond the competence areas of the respective products or services and follows up on the vision until the respective management is convinced. So far, it is unclear which actor can take on the role of the visionary, i.e., which actor has a deep understanding of the customer problem, the awareness of and access to complementary partners, as well as the required standing to convince respective management. At the same time, it is unclear how the actor is incentivized since he takes the initiative and is not initially commissioned for his service. The **sparring partner** addresses the same processes as the visionary but takes a supporting role. Therefore, the initiative and the drive must come from the company itself. The sparring partner supports the creation of the vision with impulses (e.g., from research), the search for suitable partners through its network and ensures a common language when convincing the respective management. Actors that can already take on this role today are, for example, research institutions or technology transfer centers. Furthermore, the **technology expert** supports the development of an appropriate competency-building strategy (make, buy or collaborate) through their specific domain knowledge. Activities include the selection of suitable technologies, the assessment of technology maturity level, the search for and evaluation of potential competence providers, and the support of companies in the sustainable development of in-house competencies. Lastly, the **ecosystem maker** (e.g., standardization organizations or industry associations) provides the platform for the definition of standards, thus promoting the establishment of ecosystems as scalable marketing opportunities arise.

In the formation phase, the **facilitator** contributes to the formation of the collaborative initiative through mediation as well as an explanation of appropriate technical and legal frameworks for collaboration. Stressing the essential elements of the agreement and providing appropriate frameworks reduces the partners' uncertainty or fear of being deceived. Moderation and mediation contribute to effective consensus building by avoiding stalemate situations, enabling appropriate communication between the parties, and preventing

the emergence of distrust in negotiations. The **benefit assessor** (e.g., management consultancy) supports the decision of the management or the shareholders by objectively evaluating the benefits of the collaborative initiative through developing a business plan for the respective companies.

In the operation phase, the **cooperation management support** assists partner monitoring and coordination, thus increasing implementation speed and reducing transaction costs. In doing so, the neutral third party ensures a systematic approach and contributes its methodological expertise and experience to the planning and synchronization of activities as well as to the design of the organizational model. In addition, it reduces friction in collaboration through mediation between cultures and stakeholders, e.g., through common language, as well as by identifying, addressing, and resolving conflicts early on based on impartial information about objective partner behavior and subjective partner satisfaction. The **orchestrator** has equivalent tasks to the cooperation management support but takes primary responsibility for them and is not just in the supporting role. Against this role, it is argued that in the collaborative implementation of PSS, the actor with the greatest relative benefit should be the orchestrator, as this actor has the greatest incentive for success. The **mediator** (e.g., legal advisor) is called in when conflicts arise with the task of resolving them out of court and avoiding stalemate situations.

In total, nine potential fields of application of the neutral third-party approach in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems were identified. Compared to the neutral third-party roles in existing literature, we identified three new roles—visionary, ecosystem maker, and benefit assessor. At the same time, experts did not mention the following four potentially suitable roles described in literature—(1) trust transfer to parties that lack a history of prior relationship, (2) provide trilateral governance if transaction is not worth drawing an extensive contract for, (3) reputation management and blocking exit for deviant parties, (4) timely and minimally-destructive relationship termination [9].

Overall, the relevance of the neutral third-party approach for increasing the collaboration quality and the cooperation performance is rated medium or better by about two-thirds of the interview participants (Table 4). In rating the relevance as none, very low or low, it was argued that other factors were more important. At the same time, it can be assumed that the ranking is due to the fact that the approach is not yet established in practice and therefore lacks references.

Table 4: Relevance of neutral third-party interaction for increasing collaboration quality and cooperation performance

Relative frequency of rating					n=29
None	**Very Low**	**Low**	**Medium**	**High**	**Very High**
10%	7%	17%	34%	24%	7%

4.2 Requirements for the practical implementation of the neutral third party approach in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems

This chapter presents the fields of action identified, discussing the practical application of the neutral third-party approach with the experts. Building on the results, we derive requirements to transfer the approach into practice or make it more accessible to practice. Figure 1 shows that the most frequently stated field of action is solution awareness (72%), followed by value transparency (62%). Problem awareness (38%), search and selection process (21%), as well as competency evaluation (21%), are mentioned less frequently.

Solution awareness: So far, companies have individual ideas for fields of application for the neutral third-party approach. However, they lack a complete overview of suitable fields of application, operationalizable role profiles (competence profiles, tasks, interaction type and intensity, transaction governance), and suitable actors that efficiently and effectively address the challenges of collaborative implementation of PSS. In

connection with this, it is not possible to identify suitable actors who qualify as neutral third parties, as concrete role profiles for actor evaluation are not available.

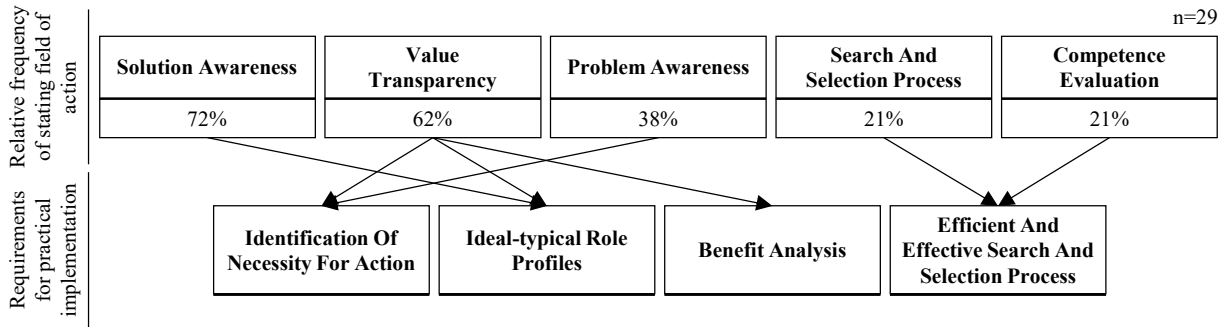

Figure 1: Requirements for the practical implementation of the neutral third party approach in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems

Value transparency: Companies cannot assess in which cases it is reasonable to work with neutral third parties and in which cases it is not. This is because the value of interacting with neutral third parties is non-transparent because there is a lack of sufficient understanding of the problem to be solved and the solution provided. If the added value cannot be made transparent, reservations such as "we don't need any help; we can do it ourselves" cannot be overcome.

Problem awareness: Companies fail to recognize collaboration challenges in time or cannot assess the necessity for action because they often lack experience regarding the collaborative implementation of PSS.

Search and selection process: If the effort to find and contract neutral third parties is too high, the approach will not be used. In this context, it is unclear what an efficient process looks like that is accepted by all cooperation partners so that the credibility of the neutral third party is not compromised.

Competence Evaluation: The evaluation of the competence of the neutral third party prior to the delivery of knowledge-intensive services with a high degree of individualization and customer integration is difficult, which usually makes trust the deciding factor. Nevertheless, risks must be limited as far as possible.

In summary, five fields of action were identified during the expert interviews, confirming the results of the literature synthesis by SCHMITT ET AL. (2022) in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems and extending it by identifying the highest relevance of the fields of action "solution awareness" and "value transparency" [18]. Building on these results, four requirements for the practical implementation are derived.

Identification of necessity for action: Support in identifying collaboration challenges and assessing the cooperation partner’s capabilities to manage these challenges.

Ideal-typical role profiles: Operationalizable role profiles (competence profiles, tasks, interaction type and intensity, transaction governance) meeting the need for effectiveness and efficiency. Ideal types serve as a basis for evaluating current actors in terms of suitability for the respective neutral third-party role and, as an ideal type, serve as an orientation for existing as well as emerging actors seeking a neutral third-party role.

Benefit analysis: Method for evaluating interaction with neutral third parties in the context of the demand holder to enable an informed make or buy decision as well as to contribute to the persuasion of the demand holder of the neutral third party approach.

Efficient and effective search and selection process: Efficient and effective process accepted by all cooperation partners so that the credibility of the neutral third party is not compromised, including methodical guidance for evaluating the competence of neutral third parties in the selection process.

5. Conclusion and outlook

This paper aims to develop a better understanding of the fields of application and the requirements for the practical implementation of the neutral third-party approach in the context of the collaborative implementation of PSS in mechanical engineering business ecosystems. Accordingly, it contributes to the transfer of the neutral third-party approach into practice and thus increases the success of collaborative initiatives in business ecosystems. This paper adds to existing research in three ways. First, the expert interviews show that challenges to the successful implementation of PSS in mechanical engineering business ecosystems arise throughout all phases—initiation, formation, and operation. However, the most significant challenges relate to the initiation and formation phases. Second, based on the challenges stated, nine potential fields of application for the neutral third-party approach were identified. That is three new fields of application compared to the existing literature. Third, discussing the practical implementation of the neutral third-party approach with the experts, four requirements for the practical implementation are derived.

This investigation has a number of limitations opening up promising avenues for further research. The findings of this investigation are subject to the single respondent bias. In addition, since there is no clear indication of the composition of the population, it is questionable whether the sample's composition is representative. Also, since the study is a point-in-time recording, the focus of the challenges may shift with the further emergence of collaborative implementation of PSS in business ecosystems. To address these deficits and strengthen the generalizability of the results, we suggest further qualitative and quantitative studies in the future. Since this study identified three new roles for neutral third parties using an inductive approach, we suggest a deductive approach to review them and potentially identify further ones. Finally, requirements for the practical implementation of the neutral third-party approach were derived based on the view of the cooperation partners. In order to secure a win-win situation for cooperation partners and neutral third parties, potential neutral third parties should be consulted in further investigations.

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