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Designing Coopetition Networks for SMEs: A Service-Dominant Logic Approach

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Abstract: Small and Medium Enterprises (SMEs) play a crucial role in the European economy, representing the vast majority of businesses and a significant portion of employment. As the global business environment increasingly embraces digital supply chains, coopetition—collaborative competition—has emerged as a vital strategy for sustaining business growth and competitiveness. Despite its recognized importance, the potential of coopetition to enhance firm performance, particularly within SMEs, remains underexplored. This study aims to address this gap by developing and validating a reference model for coopetition networks specifically tailored for SMEs, utilizing the Service-Dominant framework. The research introduces a comprehensive model that guides the formation, management, and dissolution of coopetition networks throughout their lifecycle. The model is empirically validated within the Portuguese ornamental stone sector, providing insights into its practical applicability. Key findings demonstrate that the implementation of coopetition networks can significantly enhance production efficiency and operational effectiveness within SMEs. The study also highlights the critical role of technology as an enabler of service exchange and institutionalization within coopetition networks, facilitating collaborative interactions and value co-creation. While the study makes substantial contributions to the literature, it also identifies areas for further research, including the exploration of human dynamics within coopetition networks and the long-term sustainability of such networks. The findings offer valuable guidance for SMEs seeking to enhance their competitiveness and operational efficiency in an increasingly digital and interconnected business landscape.

Keywords: coopetition; instantiation; networks; service-dominant logic; service ecosystems

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1. Introduction

Small and Medium Enterprises (SMEs) are the cornerstone of the European economy, constituting 99.8% of all non-financial businesses and providing over 65% of employment within the EU27 (Muller et al., 2021). As the global business environment increasingly shifts towards digital supply chains, the concept of coopetition—where competitors collaborate—has gained prominence as a crucial strategy for business survival and growth (Di Bella et al., 2023). Despite its growing recognition in both academic research (Corbo et al., 2023) and policy discussions, coopetition's potential to enhance firm performance remains underexplored in the context of SMEs (Bouncken et al., 2024).

Current literature extensively examines coopetition through various theoretical frameworks such as Game Theory, Resource-Based View, Paradox Theory, Transaction Cost Theory, and Network Theory, offering valuable insights into its economic, strategic, and organizational aspects (Meena et al., 2023). However, a critical issue persists: a report by the BCG Henderson Institute published in the MIT Sloan Management Review (2019) highlights that approximately 85% of coopetition networks fail to achieve their long-term objectives across eleven sectors (Reeves et al., 2019). This high failure rate underscores the fragility of these networks, particularly over the long term.

While large enterprises often play pivotal roles in sustaining coopetition networks, effectively acting as keystones that support and benefit from the ecosystem (Razmdoost et al., 2023), SMEs face distinct challenges (Destefanis et al., 2023). Unlike their larger counterparts, SMEs typically lack a dominant player within their networks, making it difficult to sustain coopetition. The literature suggests various approaches to enhance interdependence and ensure the longevity of these networks (Shao & Cao, 2024), yet there is no consensus on a robust and adaptable model tailored to the unique needs of SMEs (Bouncken et al., 2024).

This paper seeks to fill this gap by developing and demonstrating a reference model for coopetition networks specifically designed for SMEs. Leveraging the Service-Dominant (S-D) Logic framework, which emphasizes reciprocal value propositions and co-creation over traditional transactional exchanges (Stephen L. Vargo et al., 2024), this study aims to create a model that facilitates effective resource exchange and mutual value creation within SME networks. To address the research gap, this paper will pursue several key steps in a streamlined and systematic manner.

First, the literature review will ground the concept of coopetition networks within the framework of S-D Logic. This approach will position these networks as ecosystems for value co-creation, describing them as dynamic service ecosystems that evolve from initiation through to dissolution. By integrating S-D Logic, the study highlights how coopetition networks enable reciprocal value creation among SMEs, fostering collaborative interactions that enhance their operational and strategic capabilities.

Building on this theoretical foundation, the paper introduces a reference model for implementing coopetition networks tailored specifically to the SME context. This model provides a structured methodology for SMEs to adopt and leverage coopetition networks effectively. It addresses the unique challenges faced by SMEs, such as resource limitations and the need for flexibility in collaborative ventures, thereby offering a practical blueprint for fostering sustainable coopetition.

To validate the reference model and instantiation methodology, a proof-of-concept (PoC) will be conducted within the Portuguese ornamental stone sector. This sector is selected for its representativeness and relevance in illustrating the practical applications of coopetition networks. The PoC will involve a detailed functional acceptance survey followed by structured data collection and analysis over predefined periods. This approach allows for a comprehensive assessment of performance metrics under traditional operations compared to those within a coopetition framework.

The study will culminate in a thorough discussion that synthesizes the findings from the PoC, explores their broader implications, and suggests directions for future research. This discussion will provide insights into the practical benefits of coopetition networks for SMEs and propose strategies for their successful adoption and integration into business practices. Ultimately, this paper aims to develop and demonstrate a robust, adaptable framework for SMEs to navigate and thrive in coopetition networks. By leveraging these networks, SMEs can enhance their competitiveness and operational efficiency in an increasingly digitalized and interconnected business landscape.

2. A Service Ecosystems View for Coopetition

Vargo and Lusch (2004) revolutionized the understanding of “service” by defining it as the application of competencies for the benefit of others, a perspective that forms the cornerstone of this approach to coopetition networks (Stephen L. Vargo & Lusch, 2004).

Building on this paradigm, S-D Logic literature further elaborates that value is always cocreated with the beneficiary (R. Lusch & Vargo, 2007). This perspective emphasizes the importance of resource integration and service exchange, coordinated and constrained by institutions and institutional arrangements, as central to value co-creation in ecosystems (S. Vargo & Lusch, 2016)

Anchored on this service ecosystem’s view, to S-D Logic, networks are formed through the spontaneous creation of spatial and temporal structures (Stephen L Vargo & Lusch, 2010). These structures emerge from the interactions of social and economic actors, influenced by institutions and technology (R. Lusch & Nambisan, 2015). These networks are characterized by adaptive interactions among actors, who are driven by the intrinsic goal of creating value and maintaining the viability of the ecosystem (R. F. Lusch et al., 2010). S-D Logic views value creation as a mutual and adaptive service provision process, self-adjustable and interconnected within a framework of shared institutions and institutional arrangements (S. Vargo & Akaka, 2012). This conceptual framework

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leads to understanding service ecosystems, where value is cocreated in a dynamic and interconnected environment (S. L. Vargo & Lusch, 2017).

Traditionally perceived as merely physical devices, the role of technology in ecosystems has undergone a significant reevaluation in recent years. Hunt (2000) emphasizes the social dimensions of technology (Hunt, 2000). He argues that social groups play a crucial role in shaping technology and, more broadly, constructing value perceptions. Complementing this view, Arthur (2009) challenges the conventional view by describing technology as a physical tool and an assemblage of practices and components aimed at fulfilling human purposes and technological advancement as the recombination of helpful knowledge (Arthur, 2009). These insights shed light on how technology, as a component of ecosystems, is not just a tool but a dynamic element shaped by and shaping social practices and value creation.

Service literature increasingly recognizes the pivotal role of technology in enhancing and transforming networks. Maglio (2009) emphasizes technology as a key enabler of innovation within service contexts (P. Maglio et al., 2009). He notes that technological advancements have been instrumental in transforming the interactions between firms. This transformation extends to creating technology-supported ecosystems, as identified by Breidbach et al. (2013), where technology plays a central role in facilitating and exploring new avenues for value creation within networks (C. F. Breidbach et al., 2013). Understanding this dynamic role of technology is crucial for coopetition networks, where technological integration can significantly influence the mechanisms of value creation and collaboration among competing firms.

The literature on coopetition networks consistently acknowledges the role of technology in fostering innovation within these networks. Rusko (2014) identifies technology-based strategic networks as vital for coopetition innovation (Rusko, 2014). Similarly, Bicen et al. (2021) emphasize technology's role as a facilitator for interaction among network members (Bicen et al., 2021), enabling the formation of shared understandings, as supported by the work of Chesbrough & Rosenbloom (2002) among other authors (Chesbrough & Rosenbloom, 2002) (Doganova & Eyquem-Renault, 2009) (Storbacka & Nenonen, 2011).

This collective viewpoint aligns closely with the S-D Logic perspective, where technology is seen not only as an enabler (operand) but also as a starter (operant) in service ecosystems, contributing to resource integration and value creation (R. Lusch & Nambisan, 2015) (Sklyar et al., 2019). In the context of coopetition networks, this dual role of technology is crucial in enabling and enhancing collaborative yet competitive interactions among firms.

3. Constructs for Coopetition Networks for Value Co-creation

Reference models are abstract representations of domain knowledge, capturing prescriptive and descriptive design knowledge pertinent to sociotechnical problems (Schermann et al., 2009). Hevner (2004) underscores the importance of substantial academic knowledge in creating relevant reference models, which are instrumental in addressing complex real-world problems (Hevner et al., 2004). In the context of coopetition networks, the performative nature of S-D Logic is particularly relevant, providing a robust framework for addressing real-world problems, especially those involving service objects, technology systems, organizations, and people collaboratively creating value (vom Brocke et al., 2020) (S. L. Vargo & Lusch, 2017). In coopetition networks, this approach facilitates the understanding and shaping of evolving value propositions among a broad system of interacting actors.

3.1. Enabling Coopetition

Orlikowski (1992) offers a nuanced understanding of the interaction between technology and organizations (W. J. Orlikowski, 1992). She posits that technology both influences and is influenced by institutional factors and the practices of social and economic actors. At the same time, S-D Logic conceptualizes a service ecosystem as a self-contained, self-adjusting system. This system comprises resource-integrating actors interconnected by shared institutional logic, facilitating mutual value creation through service exchange (Stephen L. Vargo & Lusch, 2011). This perspective emphasizes the role of institutions in value creation, drawing attention to how technology, as an operant resource, actively interacts with other resources to cocreate value and innovate services (M. A. Akaka & Vargo, 2014).

Building upon the convergence of technology's role as established in S-D Logic, reference models for coopetition networks can designed for practical applications. Supported by the foundational principles of S-D Logic, this reference model must integrate the crucial role of technology, reflecting its importance in service ecosystems. Transporting this service ecosystem perspective to networks, it allows the synthesis of diverse viewpoints into a cohesive framework emphasizing the integration and application of resources as central to value creation, driving interactions and exchanges in coopetition networks.

3.2. Actors and Resources in Coopetition

Embracing the S-D Logic perspective, it is recognized that all economic and social actors function as resource integrators (R. Lusch et al., 2016). Under this view, service ecosystems comprise a variety of actors, such as customers, providers, and competitors. These actors apply specialized competencies through deeds, processes, and performances and integrate multiple resources, including market-facing, technological, financial, and public resources, thereby creating value (R. F. Lusch et al., 2010) to cocreate mutual benefits, establishing economic relations fundamentally based on service exchange (Stephen L. Vargo & Lusch, 2008) (Stephen L. Vargo & Akaka, 2009). In these ecosystems, technology is a resource that plays a crucial role in these exchanges. It is an integral element, enabling individuals and organizations to participate in the value-creation process and function as resource integrators within these networks (Chandler & Vargo, 2011).

Transposing this perspective to coopetition networks, the traditional roles of providers and competitors often converge, leading to a unique dynamic where providers can also become competitors and vice versa (Afuah, 2004). Within these networks, firms, customers, and other actors engage in economic exchanges, each acting as resource-integrating, service-providing entities. This collaboration is driven by a shared value co-creation goal (Stephen L. Vargo & Lusch, 2014). Arguably, actors in coopetition networks integrate resources in a manner that can be characterized by a loosely coupled architecture that facilitates the formation of service and information flow frameworks, thereby creating value networks (Zott & Amit, 2008). Value creation within these networks occurs through dynamic interactions among multiple entities. Actors continuously configure resources to initiate and sustain interactions that lead to the creation of value (P. P. Maglio & Spohrer, 2013).

Expanding upon the S-D Logic's classification of resources, the service literature recognizes any potentially useful entity, tangible or intangible, as a resource. This encompasses aspects like ephemerality and the cost of usufruct, especially pertinent in coopetition networks (J. C. Spohrer & Maglio, 2010). Building on this S-D Logic understanding can be identified the actor and resources' constructs for coopetition networks for value co-creation:

Construct #1 (actors as resource integrators) **-** The first construct posits that actors, in coopetition networks, function as resource integrators. They actively engage with available resources to create value for themselves and others, fostering new and improved ways of value creation (R. Lusch & Vargo, 2007). Systemic mechanisms underpin this process of resource integration. These mechanisms facilitate service exchanges, ensuring that all actors in the ecosystem can act as resource integrators. This is achieved through reconfiguring access rights and forming mutually agreed-upon value propositions (Stephen L. Vargo & Akaka, 2009) (Stephen L. Vargo & Lusch, 2014).

Construct #2 (technology as o**perant and operand resource)** - The second construct explores the dual role of technology in coopetition networks. Technology serves both as a facilitator or enabler (operand) and as an initiator or actor (operant) (Barile et al., 2019) (Pakkala et al., 2020) (M. A. Akaka & Vargo, 2014). As an operant resource, technology initiates and drives new forms of interaction and value creation. As an operand resource, it facilitates and supports these processes, enabling actors to engage more effectively in coopetition networks ((Nambisan, 2013). This positioning of technology allows actors, such as rival firms and individual customers, to extend and reconfigure their patterns

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of resource integration. It enables them to access resources across rival firms in a mutually beneficial manner, thereby facilitating value creation in the network (Sklyar et al., 2019). This strategic use of technology can be instrumental in alleviating the inherent tensions in coopetition networks, as it fosters a more collaborative, transparent and integrated approach to resource sharing (Raza-Ullah et al., 2014).

3.3. Service-exchange in Coopetition Networks

In the realm of S-D Logic, service exchange among actors is fundamental to the emergence of value (S. Vargo & Akaka, 2012). This perspective is echoed broadly in service literature, emphasizing the centrality of service exchange and resource integration in economic exchanges (C. Breidbach & Maglio, 2016). This view is central to this reference model. Value co-creation occurs within networks of relationships and resources, understood as a dynamic process involving resource integration, application, and transformation (Pongsakornrungsilp, 2010).

Understanding how economic actors engage in value co-creation necessitates focusing on the knowledge mechanisms and processes involved in resource integration (Payne et al., 2008). Maglio and Spohrer (2007) underscore the significance of the rights nature of resources, pointing out the crucial distinction between resources capable of entering contracts or agreements and those that cannot (J. Spohrer et al., 2007). This distinction is crucial as only people and firms, as imputable actors, can legally bind themselves in such ways. They further argue that specific configurations of resources can actively initiate interactions, adding a dynamic layer to how resources are utilized in economic exchanges (P. P. Maglio & Spohrer, 2008). In scenarios where complex resource configurations lead to initiating actions, people and technology collaboratively compute and adjust to the evolving value of knowledge, reflecting the dynamic nature of service ecosystems (J. C. Spohrer & Maglio, 2010).

As envisioned in S-D Logic, the service process is inherently interactive and collaborative, involving multiple economic actors ((S. Vargo & Akaka, 2012). This perspective aligns with the broader view that all social and economic actors are resource integrators (Stephen L. Vargo et al., 2020). Successful value co-creation hinges on the ability of these actors to engage in meaningful interactions. This involves exchanging resources and integrating them effectively within their contexts (Prahalad & Ramaswamy, 2000).

The efficacy of these interactions, and thus the value cocreated, is contingent upon each actor's capability to exchange and apply service information in relevant and beneficial ways within their respective realities (Ballantyne & Varey, 2006). Building on this foundational understanding of service exchange among rivals can be identified the second set of constructs for coopetition networks for value co-creation:

Construct #3 (interactions among rivals) - In coopetition networks, rival interactions are critical in value co-creation. Integrating technology, both as operant and operand resources, is instrumental in simultaneously facilitating cooperation and competition among rivals (Tidström, 2014). Reliable technology serves as a guide and enabler in formulating proposals between competitors. It allows rivals to rely more on objective, technology-driven processes rather than direct interactions with competitors, thereby increasing the likelihood of mutual acceptance of proposals and reducing direct competitive friction. This indirect approach facilitated by technology enhances the probability of acceptance and successful collaboration among rivals, leading to more effective and efficient value co-creation.

Construct #4 (service-exchange intensity) – In coopetition networks, the intensity of service exchange is essential to enhance the co-creation of value. Integrating competitors' resources, facilitated by operant and operand technology, can significantly amplify this intensity (Storbacka & Nenonen, 2011) (Ng & Wakenshaw, 2017). This heightened level of resource integration aligns with the broader value creation process, as conceptualized in S-D Logic. Value creation in this context arises from intricate value configurations, constantly refined and enhanced through the interactions among rival actors (Stephen L Vargo & Lusch, 2010).

Within service ecosystems, the interplay among actors at multiple levels significantly enhances the value cocreated. Arguably, increasing interactions in coopetition networks within and across

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different aggregation levels contribute to a more dynamic and enriched value co-creation process (Stephen L Vargo & Lusch, 2008).

3.4. Coopetition Networks as a Particular case of Service Ecosystems

In service ecosystems, institutions are understood as humanly devised rules, norms, and beliefs. These elements enable and constrain actions, thereby making social life predictable and meaningful, as described by Scott (2008) and further elaborated by Vargo and Lusch (2016) (Scott, 2013) (S. Vargo & Lusch, 2016).

Building upon this foundational understanding, S-D Logic literature has evolved to adopt a dynamic perspective that focuses on how institutions shape value creation through service exchange, offering insights into the structural intricacies of ecosystems that go beyond dyadic or micro-level interactions (Chandler & Vargo, 2011) (S. Vargo & Lusch, 2016). According to the S-D Logic, this institutional view is crucial for comprehending how value is cocreated in service ecosystems, as it provides a lens to understand the broader, systemic interactions and constraints that shape economic and social exchanges.

Establishing a bridge between technology and knowledge, in a broader sense, technology is often applied to enhance and utilize valuable knowledge (Mokyr, 2002), further positing that knowledge itself forms a part of the institutional structure of society, an idea echoed in S-D Logic ((S. Vargo & Lusch, 2016). Moreover, drawing from Simon's (1988) concept of design as resource reconfiguration to address problems (Simon, 1988), technology resources can be viewed as assemblages of practices and components to fulfil human purposes (Arthur, 2009). In this context, social technologies are often conceptualized as institutions (Nelson & Nelson, 2002). Orlikowski (2000) provides a nuanced view of this interplay, describing how technology and actors collaboratively affect, transform, and maintain institutions (Wanda J Orlikowski, 2000). Drawing on Giddens' (1984) structuration theory, this perspective positions technology as both a product and an enabler of human action (Wanda J. Orlikowski, 1992). This conceptualization of technology as an institutional phenomenon aligns with the S-D Logic perspective on institutions within service ecosystems (S. Vargo et al., 2015), from which it may be argued that in the context of coopetition networks, technology can facilitate institutionalization, enabling interactions among rivals while also helping to manage and constrain potential tensions. Building on this foundational understanding of the service ecosystem can be identified two additional constructs for coopetition networks for value co-creation:

Construct #5 (technology as institutionalization mechanism) - This construct explores the role of technology as a mechanism for institutionalization within coopetition networks. This involves viewing and using technology as both an operand (enabler) and operant (initiator) resource in the process of value creation (R. Lusch & Nambisan, 2015), (S. L. Vargo & Lusch, 2017) (Barile et al., 2019). Drawing from Simon's (1988) concept of designed artefacts, technology systems are not just tools but repositories of embedded knowledge and skills, as discussed by Wanda J. Orlikowski (1992). In this capacity, technology acts as an institutionalization mechanism, facilitating the endogenous generation of new institutions. This is crucial for shaping the context in which resource integration and service exchange occur, enabling effective coopetition and value co-creation in ecosystems (S. Vargo et al., 2015).

Construct #6 (institutionalized networks) – As coordination mechanisms, institutions are crucial in coopetition networks. Here, operant and operand technology are facilitators of interaction among rivals and act as mechanisms for institutionalization within service ecosystems (S. Vargo & Lusch, 2016). Once institutionalized, the coopetition networks are guided by sets of institutions or institutional arrangements that shape the thinking and behaviour of the actors by providing a framework of value assumptions, cognitive frames, rules, and routines, thereby establishing nested and interlocking service ecosystems. Within this framework, operant and operand technology are not just tools but are conceptualized as repositories of potentially helpful knowledge. This knowledge is instrumental for future interactions within service ecosystems, facilitating the exchange and innovation (S. Vargo et al., 2015). This perspective on institutionalized networks is particularly relevant in dynamic and changing industries. Innovations, characterized by loosely coupled systems, enable rapid adaptation and evolution of behaviour patterns, often keeping pace with or outstripping the rate of technological advancements (M. A. Akaka & Vargo, 2014).

4. Coopetition Networks Lifecycle

A key component of a reference model is its lifecycle, which delineates the various stages a coopetition network undergoes from inception to dissolution. Figure 1 illustrates this lifecycle, providing a visual representation of each stage.

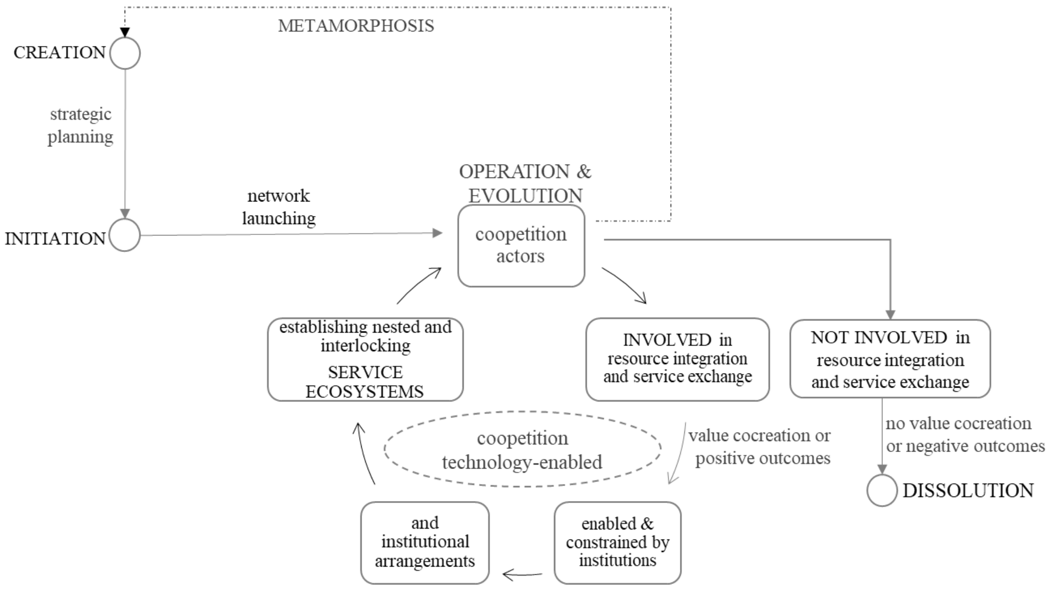

Figure 1. Coopetition Network Lifecycle: A Service Ecosystems Perspective.

The Creation Stage encompasses strategic planning, governance establishment, and the development of a common ontology. It also involves setting up the necessary technology and network infrastructure. The Initiation Phase includes the installation of network infrastructure and motivator teams, launching the coopetition network, and undertaking activities like actor recruitment and conformity checking. In the Operation Stage, technology facilitates the integration of resources and service exchange among rivals. This stage is characterized by forming service ecosystems driven by the actors' interactions within the network. The Metamorphosis Stage The metamorphosis stage is prompted by significant changes within the network, necessitating a strategic overhaul and potentially leading to the network's relaunch. The Dissolution Stage is when the network ceases to create value or when the value generated falls short of the actors' expectations, leading to disengagement and the eventual collapse of the service ecosystem - the actors rapidly quit involvement in resource integration and service exchange, resulting in in in in the service ecosystem death and consequent coopetition network closure.

Linking value co-creation to resource integrators (actors) to service exchange (S. Vargo & Akaka, 2012), a coopetition network can be viewed as a relatively self-contained, self-adjusting system of resource-integrating rivals and customers connected by technology that ensures institutional arrangements for mutual value creation through service exchange (S. Vargo & Lusch, 2016).

5. Coopetition Networks Instantiation

Instantiation refers to the process of creating a specific occurrence or realization of an abstract concept. It involves developing a concrete instance or application based on a theoretical reference model or architecture. In the case of this research, the instantiation process is applied to coopetition networks. This process involves characterizing new technology-based networks by leveraging the lifecycle outlined above and considering the unique aspects of coopetition. The instantiation process for coopetition networks encompasses a systematic set of steps. These steps are designed to specify and generate a customized version of the coopetition networks for value co-creation, fully describing its components. Collectively, these components constitute an instance of the reference model, operationalizing the theoretical framework within a practical context.

5.1. Initiation Stage

The Initiation Stage of coopetition networks for value co-creation is the starting phase. It can be subdivided into creation and initiation phases, each with distinct objectives and activities (Figure 2).

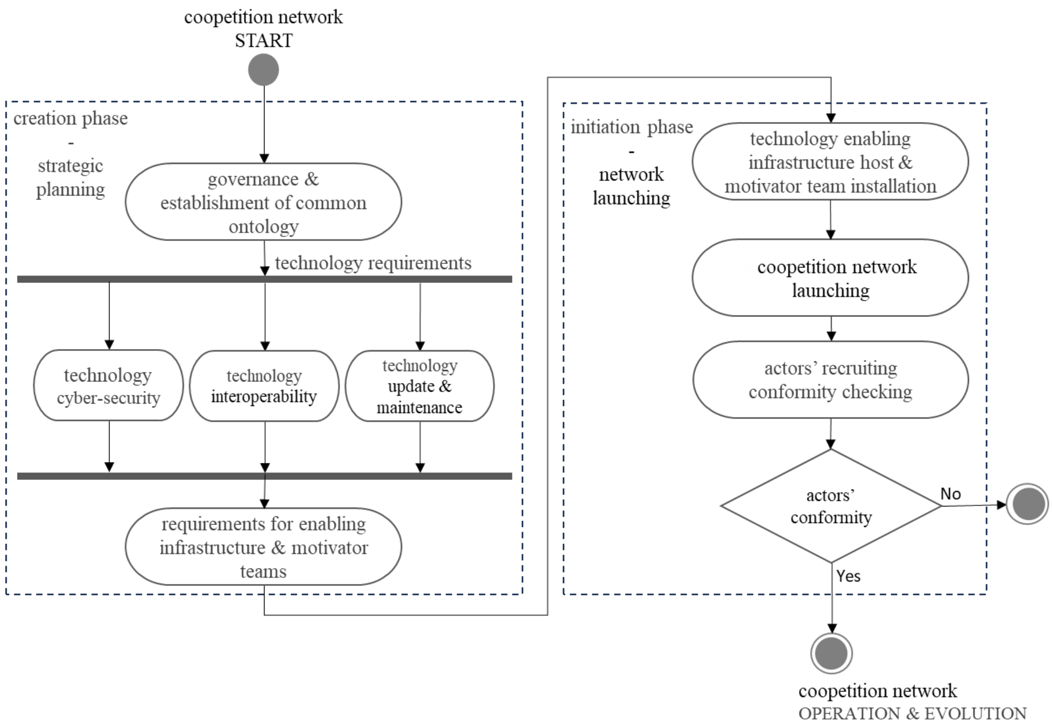

Figure 2. The Initiation Stage of the coopetition networks for value co-creation.

The creation phase primarily focuses on strategic planning, starting with evaluating the environmental context. This step is essential for preparing and facilitating all subsequent operational activities. Key aspects, such as technology requirements, play a vital role at this stage, particularly in establishing a standard ontology for the network. This process includes defining governance structures, determining common ontologies, and setting technology standards and requirements, such as cybersecurity, interoperability, and maintenance protocols. The final steps in this phase involve addressing the network system's enabling requirements. This includes setting up the necessary infrastructure, hosting arrangements, and forming teams responsible for recruiting actors and motivating participation in the network.

The initiation phase is crucial in developing coopetition networks for value co-creation, focusing on network launching, infrastructure setup, and forming motivator teams for actor recruitment and conformity checking. A critical trigger for launching a coopetition network is the establishment of clear and shared expectations among the rival actors (Ghobadi & D'Ambra, 2012) (Dagnino & Padula, 2002). This phase ensures that the management principles and the common ontology, previously established in the creation phase, are well-understood and committed to by all participating actors. Moreover, the network's initiation involves the network motivator team setting up the necessary technology-enabling infrastructure. This setup is a foundational step that precedes the actual launching of the coopetition network. Following the network launch, the focus shifts to recruiting actors and checking their compliance with essential requirements. This process includes thorough interoperability and cybersecurity assessments to ensure that each actor's technology aligns with the network's standards and is fully compliant.

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5.2. Operation Stage

The Operation Stage represents the phase when coopetition networks for value co-creation come into existence. Their evolution involves the recruitment and integration of resources for service exchange among rivals. These networks operate within the S-D Logic framework of institutions and institutional arrangements, forming interconnected service ecosystems.

Micro-Level (network activity): When an actor (rival) engages with technology, it gains the capability to integrate its skills, knowledge, operand resources, and other resources voluntarily. These actors engage in service exchange with others in the network, involving multi-level interactions. The interactions are enabled and constrained by the institutions and institutional arrangements endogenously generated at a meso-level.

Meso-Level – (institutions) - at a meso-level, some behaviour patterns start to appear (institutions) as humanly devised rules, norms, and meanings guiding and shaping the interactions among actors in the network. Coordinated by these institutions and institutional arrangements sets, a service ecosystem of actors is established, creating the context for future resource integration and service exchange involving more rivals (Figure 3).

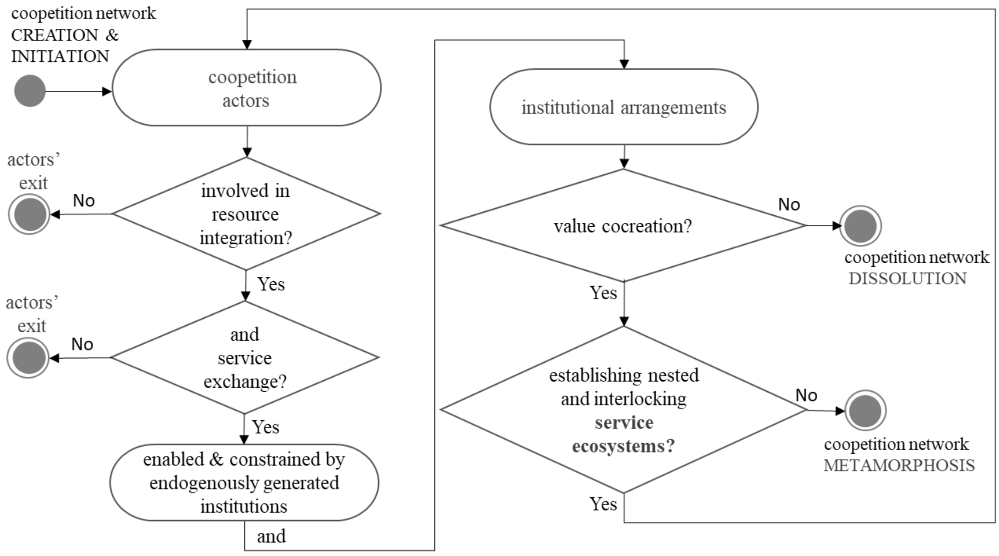

Figure 3. The Operation and Evolution stage of the coopetition networks for value co-creation.

This resource integration view within coopetition networks for value co-creation is guided by five fundamental axioms of S-D Logic (M. Akaka et al., 2013), which illuminate the intricate and dynamic context in which value is cocreated in service ecosystems (S. Vargo & Lusch, 2016). (1) Service is the fundamental basis of exchange: This axiom emphasizes that all economic and social activities can be viewed as services exchanged between actors. (2) Value is cocreated by multiple actors, always including the beneficiary: This axiom highlights that value creation involves collaboration among various actors, with the beneficiary playing a central role. (3) All social and economic actors are resource integrators: This axiom recognizes that actors in service ecosystems integrate and utilize resources to cocreate value. (4) Value is always uniquely and phenomenologically determined by the beneficiary: This axiom underscores that the perception of value is subjective and varies from beneficiary to beneficiary. (5) Value co-creation is coordinated through actor-generated institutions and institutional arrangements: This axiom emphasizes the role of institutions and arrangements in guiding and coordinating value co-creation.

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5.3. Metamorphosis Stage

The metamorphosis stage represents a crucial phase in evolving coopetition networks for value co-creation. Coopetition networks undergo strategic adaptations during this stage to respond effectively to evolving market conditions and maintain competitiveness (Figure 4).

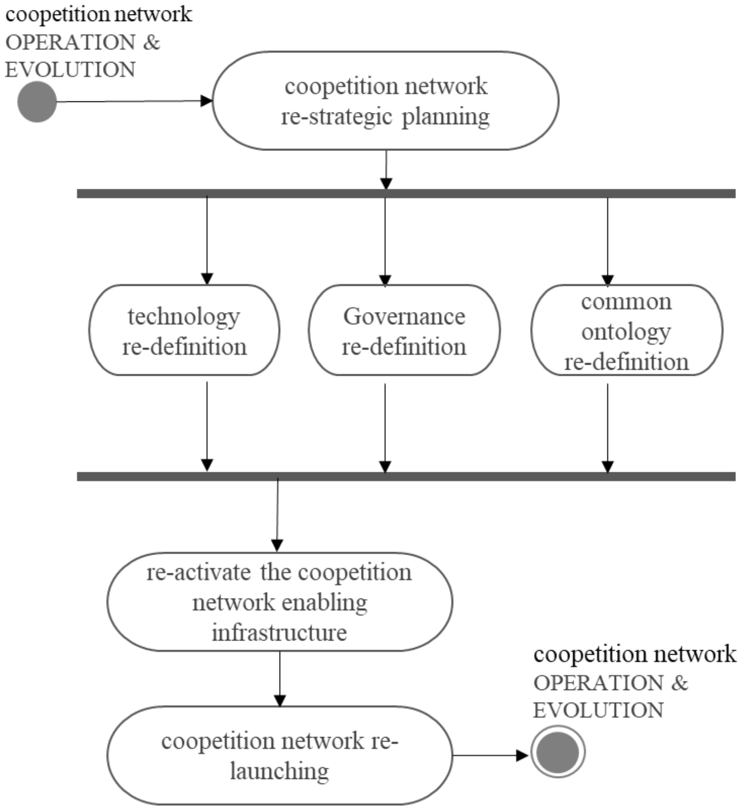

Figure 4. Metamorphosis stage of the coopetition networks for value co-creation.

Among other reasons behind a coopetition network starting a Metamorphosis Stage, it may be found that (1) Network Reshaping: A coopetition network undergoes a transformation or reshaping process. This transformation is triggered when the existing institutions and institutional arrangements within the network cannot establish the desired nested and interlocking service ecosystems; (2) Identifying the Need for Change: The network's leadership and stakeholders recognize the need for change. This recognition may stem from challenges in achieving the intended service ecosystems, changes in market dynamics, or other factors affecting the network's performance. (3) Strategic Planning: A new strategic plan addresses the identified issues and challenges. This plan outlines the changes, improvements, or innovations needed to enhance the network's competitiveness and value creation capabilities; (4) Improving Key Components: The strategic plan may focus on various aspects, including technology enhancements, governance adjustments, ontology refinement, and other relevant issues. These improvements aim to boost the network's capacity to create value through service ecosystems; (5) Reactivation of Network Infrastructure: Once the strategic planning phase is completed, the network-enabling infrastructure is reactivated. This involves implementing the technological, structural, and organizational changes outlined in the strategic plan. (6) Re-launching: The network undergoes a re-launching phase with the updated infrastructure. This phase signifies the network's readiness to operate under the new strategic framework. (Re)Initiation Steps: The (re)initiation steps are carried out to ensure that all actors and stakeholders are aligned with the revised plan. This may involve recruiting new participants, reaffirming commitments, and conducting interoperability and cybersecurity checks to ensure compliance with the updated technology requirements. In summary, the Metamorphosis Stage is a pivotal phase in the life of a coopetition network for value co-creation. It involves adapting the network's strategy, technology, governance, and ontology to respond effectively to changing

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market conditions and trends. By embracing these adaptations, the network aims to remain competitive and continue its mission of value creation through service ecosystems.

5.4. Dissolution Stage

The Dissolution Stage, illustrated in Figure 5, signifies the network's closure when its activities cease. This stage is typically triggered when the network's value creation exceeds the actors' expectations. In response, actors withdraw from resource integration and service exchange activities, leading to the eventual death of the service ecosystem and the closure of the coopetition network.

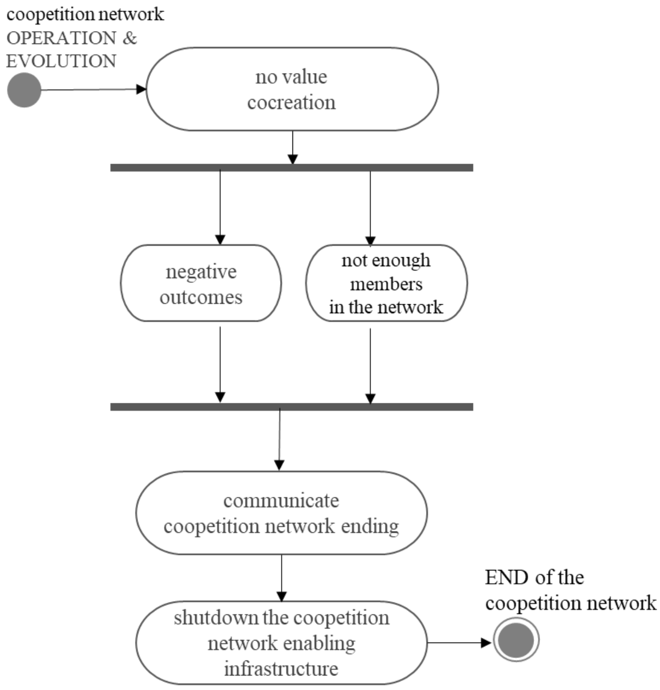

Figure 5. Dissolution stage of the coopetition for value co-creation.

During the dissolution process, the primary focus is concluding affairs and contracts with all participants, including customers. This involves shutting down the coopetition-enabling infrastructure and formally announcing the network's closure, thus marking the end of the network's lifecycle.

6. Coopetition Networks for Value Co-creation Demonstration

The ornamental stone sector, a pillar of Portugal's esteemed cultural heritage and progressive innovation, has played a pivotal role in the creation of iconic stone monuments worldwide since the 15th century (Carvalho & Lisboa, 2018). Recent figures from the Portuguese Stone Federation (2022) highlight the sector's notable economic influence: exporting to 116 countries, it is ranked as the ninth largest in the World International Stone Trade and holds the second position globally for international trade per capita (Silva & Marques Cardoso, 2023). With exports exceeding imports by 660% and a substantial portion of these exports destined for markets outside Europe, the industry generates a turnover of €1.230 million. It provides over 16,600 direct jobs, serving as a vital source of employment, especially in inland regions (Silva & Pata, 2022).

6.1. Acceptance Survey

To assess the acceptance level of the coopetition network reference model among Portuguese ornamental stone companies, a survey was conducted across a sample representing 16.2% of the industry. These SMEs are recognized for their substantial contributions to the economy and

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innovations in digital technologies (Silva et al., 2020). For the study, each participating company was assigned a digital level (DL) based on site visits.

DL#0: No digital machines are used. DL#1: At least one computerized machine on the manufacturing floor. DL#2: All machines are computerized. DL#3: All machines are computerized and connected to the SME management system. DL#4: All machines are connected and can interface with Building Information Modelling (BIM) architects' stations.

The evaluation involved a thorough assessment of each company's digital production equipment, management practices, integration processes with production, and participation in digital marketplaces. The survey was organized into four key actions: (1) Introduction - emphasizing the industry's transition to BIM platforms and the imperative for stone companies to scale up, offer competitive pricing, and ensure rapid delivery. (2) Hypothesis - presenting a theoretical scenario where companies join a network technology that facilitates market search collaboration with competitors while maintaining commercial confidentiality. (3) Question - inquiring if companies would be willing to collaborate with competitors under the proposed "network technology" framework. The survey, conducted throughout 2023, assessed the willingness of companies at various DLs to join such networks under a proposed "network technology" that ensures market search collaboration with competitors while maintaining commercial confidentiality.

The detailed breakdown of responses across different digital levels is detailed in Figure 6. The results indicate that 64.9% of respondents expressed a positive inclination towards joining coopetition networks, signifying a general acceptance of the reference model. This widespread acceptance underscores the industry's recognition of the potential benefits of such collaborations in enhancing scale, competitive pricing, and rapid delivery.

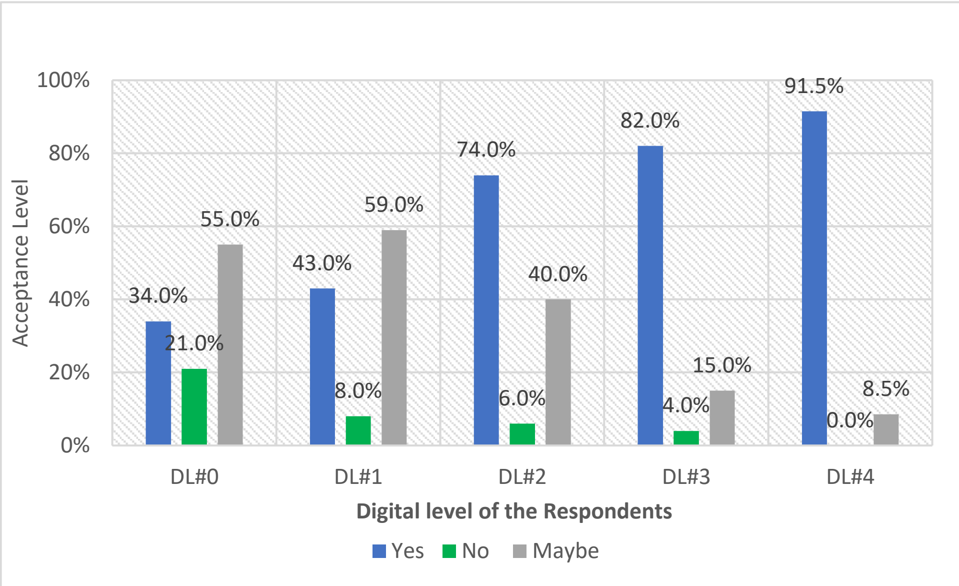

Figure 6. Functional Acceptance of Coopetition Networks for Value Co-creation.

A detailed analysis of the findings reveals a strong correlation between a company's digital maturity and its inclination to participate in coopetition networks. Companies with higher digital maturity levels (DL#3 and DL#4) exhibit a notably higher acceptance rate of 86.8%, highlighting the crucial role of digital advancement in promoting openness to collaborative innovations. These digitally advanced companies, equipped with integrated computerized systems and BIM capabilities, are clearly more adept at leveraging technological networks for value co-creation. In contrast, only 7.8% of respondents showed a reluctance to join the proposed networks, indicating minimal rejection of the hypothesis. This low rejection rate further underscores the broad recognition of the strategic benefits that coopetition networks can offer.

This favourable initial assessment of coopetition networks for value co-creation, particularly among DL#4 respondents, paves the way for advancing to the proof-of-concept (PoC) stage.

6.2. Proof-of-Concept (PoC)

To implement the PoC for Coopetition Networks for Value Co-creation, the previously described instantiation methodology was utilized. Given the lower acceptance rates among companies at digital maturity levels DL#0, DL#1, and DL#2, these companies are not yet prepared for integration due to a need for further development of a digital mindset. Consequently, this PoC was strategically executed in two DL#4 companies. These companies, equipped with ERP-connected machines interfacing with BIM architects' stations, were invited to participate. This setup exemplifies best practices within the Portuguese ornamental stone sector. To safeguard sensitive information, a comprehensive confidentiality agreement was established.

For demonstrating the potential of coopetition networks for value co-creation, among the numerous indicators recommended by management and manufacturing literature (Slavic et al., 2024), effectiveness was chosen as the key performance indicator (KPI_{EFFECT}) (Briglauer & Grajek, 2023). Given that this is a proof of concept, this single KPI was selected due to its relevance in incorporating the element of time. BIM has changed project management and coordination in the construction industry (Abdumutalibovich & Lutfillaevna, 2023). To meet the competitivity requirements as imposed by BIM, stone providers must improve their production effectiveness (Aliyari & Ayele, 2023). Thus, KPI_{EFFECT} was selected to assess how stone manufacturers adapt to global BIM procurement requirements. The KPI_{EFFECT} metric measures the effectiveness by calculating the ratio of daily good parts produced (GPP) to the number of production hours (PT) utilized (Equation (1)).

$$KPI_{PE}\text{ (good partes / hour)} = \sum_{1}^{n}\left(\frac{GPP_{(daily)}}{PT_{(daily)}}\right) \quad (1)$$

Improvements in KPI_{EFFECT} indicate increased production effectiveness, allowing firms to offer stone parts at more competitive prices.

6.3. Results and Discussion

This PoC employed a comprehensive data collection strategy over two separate fifty-four-day periods to evaluate the transition from state-of-the-art (SoA) practices to a Coopetition Network for Value Co-creation (CNVC) practices. The comparative analysis highlights the potential of coopetition networks to enhance performance efficiency. It demonstrates how shared resources and collaborative efforts within these networks can lead to superior operational outcomes. By improving the KPI_{EFFECT}, firms can better align with BIM requirements, co-creating value through enhanced project execution and timely delivery. This underscores the strategic advantage of adopting coopetition networks to drive value co-creation and operational excellence in the construction sector.

To collect data for assessing KPI_{EFFECT}, an Internet of Things (IoT) prototype was deployed with two ornamental stone producers (Mosch et al., 2023). This PoC aimed to showcase the benefits of coopetition networks for value co-creation. The implementation allowed these SMEs to experience enhanced digital connectivity and collaboration within their operations. Figure 7 illustrates the digital connectivity and operational synergies achieved through the network.

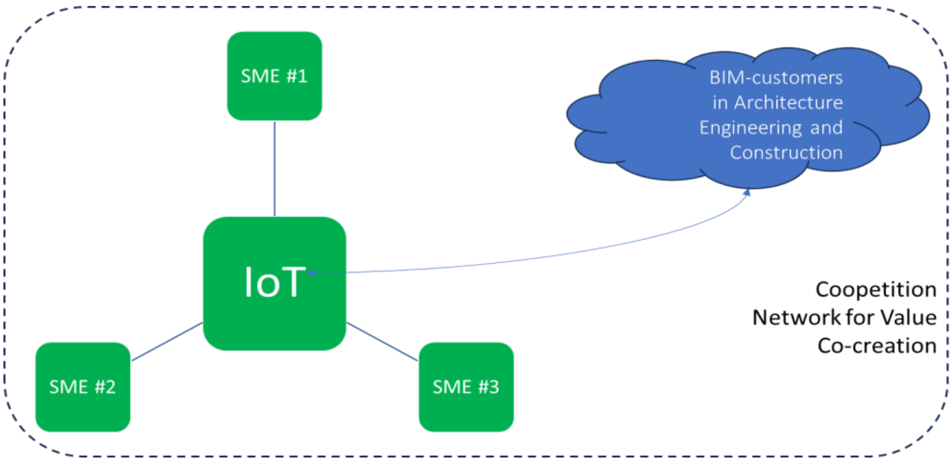

Figure 7. The IoT-enabled coopetition networks for value co-creation.

To assess the shift from SoA to CNVC, this PoC utilized a structured data collection approach over two 54-day periods. This framework facilitated a detailed analysis of KPI_{PE} before and after the implementation of the coopetition network for value co-creation.

The first phase aimed to document operational metrics under the SoA conditions. During this period, each company operated independently, managing their production and delivery processes without any collaborative interactions. This phase established a baseline of traditional practices, serving as a reference point for later comparisons.

The second phase marked the transition to a CNVC practices, where companies engaged in an IoT-enabled network. The CNVC practices blends competition and cooperation among companies, fostering an environment of shared resources and technological collaboration. Using IoT technology, companies were able to enhance their operational efficiencies and innovate together. In this phase, companies were encouraged to leverage each other's strengths and technological capabilities within a secure and adaptable framework. The structured sharing and secure communication practices fostered an environment conducive to collective innovation and operational improvement. The following practices were implemented: (1) SMEs confidentially shared and accessed each other's resources, such as stock and machinery, enabling more efficient use of assets and mutual support within the network; (2) Companies had the flexibility to join or leave the network at any time, maintaining their autonomy while participating in the collaborative ecosystem; (3) All interactions and data exchanges were conducted using secure OPC-UA protocols (Hoppe, 2023), ensuring confidentiality and protection of proprietary information; (5) Companies provided and gained access to resources based on a reciprocal model, fostering cooperation while preserving competitive integrity; and, (6) The network was designed to seamlessly integrate with BIM systems used by architects (Wijeratne et al., 2024), enhancing coordination across different stages of production and delivery.

Throughout this phase, adherence to confidentiality agreements was critical. All data were stored and handled to ensure privacy and security, facilitating a robust evaluation of the impact of CNVC on operational efficiencies.

Data were collected and managed rigorously, with a focus on privacy and security compliance. All data were anonymized and referenced only by company labels. Collection, recording, and export procedures were meticulously followed, with results stored in Excel files for secure and consistent handling. This approach enabled a detailed analysis while safeguarding the privacy and proprietary information of the participating companies.

By contrasting operational metrics between SoA and CNVC phases, the study aimed to highlight the tangible benefits of coopetition practices within SMEs. Table 1 summarizes the collected data.

Table 1. Summary of Data Collected During the Proof-of-Concept.

Data	Description	Daily average (SoA)	Daily average (CNVC)
Data 1	Good Parts Produced (good parts)	299.2	415.8
Data 2	Production Time (hours / day)	13.3	13.3
KPI_{EFECT}	Efficiency (good parts / hour)	22.48	31.20

Under the SoA conditions, the KPI_{EFECT} was 22.48 good parts per hour. During the CNVC phase, this efficiency significantly increased to 31.20 good parts per hour, representing a substantial gain of 38.8%.

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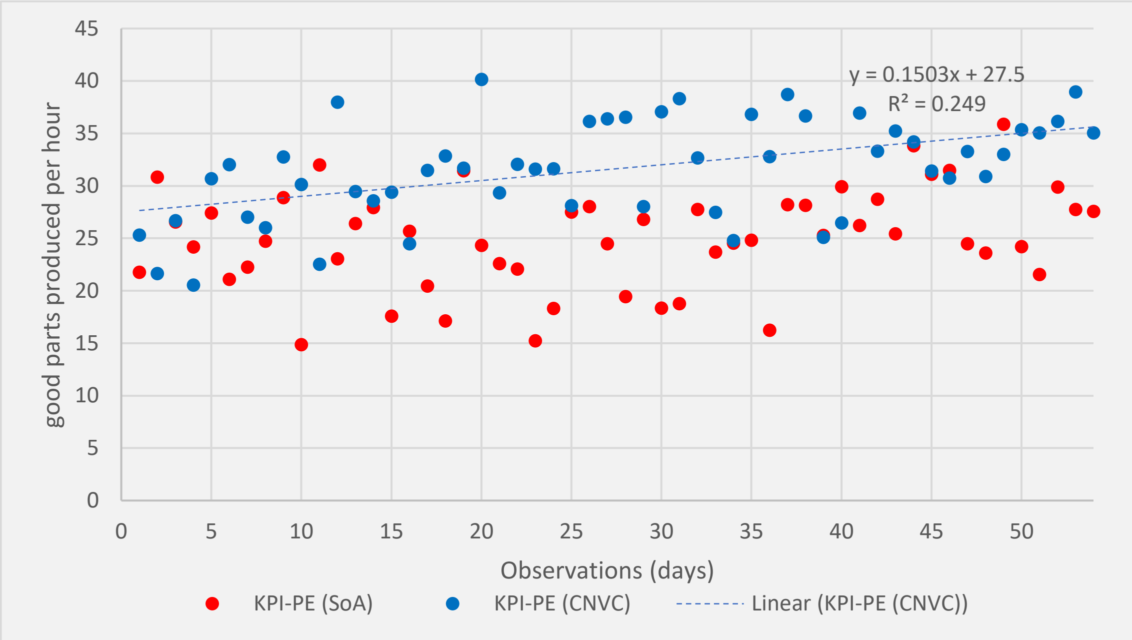

Figure 8. Impact Trend of Coopetition Networks on Performance Efficiency (good parts per hour).

These results show a moderate positive correlation between coopetition networks and performance efficiency (Pearson's r = 0.499), suggesting that as coopetition integration increases, so does performance efficiency. The trend line indicates that each unit increase in coopetition network integration boosts performance efficiency by approximately 0.1503 good parts per hour, starting from a baseline of 27.5 good parts per hour, while coopetition networks account for about 24.9% of the variability in performance efficiency. While significant, other factors also play a crucial role in influencing efficiency.

These results demonstrate that transitioning to a coopetition network for value co-creation can enhance operational efficiency, but SMEs should also consider other factors and strategies to maximize performance improvements.

This PoC confirmed the preliminary acceptance, suggesting that by addressing areas for improvement and leveraging existing strengths, the coopetition network for value co-creation concept is well-positioned to significantly influence the digital transformation of the ornamental stone sector in Portugal.

Specifically, the coopetition network enhances dynamic and secure competition networks, which are essential for navigating the evolving competitive landscapes in the industry.

7. Conclusions

This study contributes to the understanding and practical application of coopetition networks for value co-creation among SMEs by employing the S-D Logic framework. By conceptualizing coopetition within the context of service ecosystems, the research introduces a comprehensive reference model that spans the entire lifecycle of coopetition networks. This model, coupled with a systematic instantiation methodology, provides clear and actionable guidelines for forming, managing, and dissolving both nascent and mature coopetition networks.

The empirical validation of the proposed model was conducted within the Portuguese ornamental stone sector, which served as an effective testing ground due to its representativeness within the industry. The survey conducted within this sector yielded compelling results, with a 92.3% approval rate among respondents, confirming the model's acceptance and potential utility in real-world applications. This strong endorsement supports the progression to the PoC stage.

Under the SoA conditions, the KPI_{EFECT} was recorded at 22.48 good parts per hour. Under CNVC, this effectiveness increased significantly to 31.20 good, produced parts per hour, representing a substantial gain of 38.8%. This result demonstrates the tangible benefits of implementing coopetition networks in enhancing production efficiency.

The integration of S-D Logic into the study of coopetition underscores the importance of viewing technology not just as a tool but as a critical enabler of service exchange. This perspective facilitates the institutionalization of coopetition networks, enriching the discourse on service ecosystems and providing a novel lens through which to examine coopetition. It highlights the value of technology in enhancing collaborative interactions and service co-creation.

The instantiation methodology presented in this study marks a significant advancement in the field of coopetition, particularly tailored for SMEs. It equips these enterprises with a structured approach to engaging in coopetition, potentially leading to improved innovation, operational efficiency, and competitive positioning. This methodology is essential for SMEs to navigate and thrive in an increasingly digitalized and interconnected business landscape.

However, this study acknowledges several limitations that warrant further exploration. The complex and dynamic nature of human relationships within coopetition networks was not fully explored. Future research could delve deeper into how interpersonal dynamics impact the sustainability and effectiveness of these networks. Additionally, the study did not exhaustively address the implementation times, costs, and benefits associated with adopting coopetition networks. Further investigation into these factors could provide a more comprehensive understanding of the practical challenges and economic implications involved. Moreover, the long-term sustainability and broader impact of coopetition networks remain areas ripe for further investigation. Future studies could explore how these networks evolve over time and their sustained impact on firm performance and innovation.

In conclusion, this study not only addresses a critical gap in the coopetition network literature but also offers practical implications for SMEs. By providing a robust framework grounded in S-D Logic and validated through empirical research, it opens new avenues for enhancing the competitiveness and operational efficiency of SMEs through strategic coopetition. The insights and methodologies developed here lay a solid foundation for future research and practical applications in the evolving landscape of digitalized business ecosystems.

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