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Ukko Juhani, Saunila Minna

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Understanding the practice of performance measurement in industrial collaboration: from design to implementation

This study focuses on the design and implementation of a performance measurement system (PMS) for industrial collaboration. This article provides insights from two case studies of industrial collaboration. The research aims to study the crucial characteristics of PMS design and implementation in industrial collaboration, in which multiple tiers, extending beyond the buyer-supplier dyad, are considered. Prerequisites and challenges are crucial characteristics that should be examined in the design and implementation of a PMS. The results indicate three main characteristics affect the design and implementation of a PMS in an industrial collaboration: 1) the importance of collaboration, 2) the importance of coordination and integrated information systems within the system implementation, and 3) the importance of acknowledging the impact of varied customer needs.

Keywords: Performance Measurement; Performance Management; Industrial Collaboration; Supply Chain; Performance Measurement System; Buyer-Supplier Relationship

1. Introduction

The movement of industrial companies toward servitization has created new approaches to providing value through providing services that complement traditional products (Lovell and Gummesson, 2004; Bititci et al., 2012; Cavalieri and Pezzotta, 2012; Ukko et al., 2015). Such companies work in a competitive and turbulent environment that requires they collaborate to respond to customers' demands more effectively and efficiently (Bititci et al., 2004). The shift from simple (collaborative) organizations involving a few partners to complex systems of organizations working together to create value (Bititci et al., 2012) has created new prerequisites for collaboration between customers and suppliers. This open and networked operating environment makes new demands on organizational members' abilities to work collaboratively with outsiders, and organizations find it challenging to manage their own processes in parallel with the surrounding operating environment (Ramsay and Wagner, 2009; Pekkola and Ukko, 2016). Creating and sustaining competitive advantage through collaboration requires that the

collaboration structures be understood, managed, and measured (Verdecho et al., 2009). Therefore, companies must have effective and efficient performance measurement systems (PMSs). Despite the significance of collaboration as an economic engine for industrial companies, performance measurement theory has not provided extensive evidence that can help guide, monitor, and measure such entities.

Most of the previous studies on PMSs in industrial collaborations focused on supply chain performance measurement systems (SCPMSs), where only the point of view of the buyer company evaluating its suppliers is considered (Maestrini et al., 2018). Thus far, a measurement system in which both parties, the buyer and the customer, take an active role in the measurement process and collaborate in performance has not been thoroughly investigated (Koufteros et al., 2014; Melnyk et al., 2014; Maestrini et al., 2018). Even fewer studies on PMSs have been reported in which multiple tiers are considered, extending beyond the buyer–supplier dyad and configuring a multitier SCPMS (Maestrini et al., 2017). Based on this unexplored issue, they present a research gap regarding how multitier SCPMSs can be adopted, and the barriers and enablers.

This study focuses on the design and implementation of a PMS for industrial collaboration, in which the purpose of the system is similar to the purpose of a multitier SCPMS. The research aims to study the crucial characteristics of PMS design and implementation in this type of industrial collaboration. Recent studies on industrial collaboration highlight that companies operating in maintenance collaborations confront increasingly complex and dynamic interactions. This transition is due to the increasing trends of digitalization and outsourcing of maintenance. For example, instead of conducting maintenance on their own, factories buy the maintenance work from their equipment providers or companies specialized in industrial maintenance that sell service agreements or operating services for industrial plants. Managing such a transition requires strong collaboration, and these collaborations can also be significant in monetary terms. Although some studies concluded that performance measurement in such collaborations is important (Angerhofer and Angelides, 2006; Koufteros et al., 2014; Ukko and Pekkola, 2016; Maestrini et al., 2017), limited insights into the characteristics of PMS design and implementation in such collaborations exist. Thus, this study contributes by investigating PMS design and implementation in an empirical setting in the context of a business-to-business (B2B) industrial collaboration, in which multiple

tiers are considered, extending beyond the buyer-supplier dyad. We consider prerequisites and challenges crucial characteristics that should be examined in the design and implementation of a PMS. The research questions are as follows:

RQ1. What are the prerequisites and challenges in the design and implementation of a PMS in an industrial collaboration?

RQ2. How can the prerequisites and challenges be managed in the design and implementation of a PMS in an industrial collaboration?

In justifying the research design, it is apparent that by systematically developing a collaboration between relevant partners, companies can significantly improve the performance and competitiveness of their overall operations (Papakiriakopoulos and Pramadari, 2010; Liang, 2015). Furthermore, one aspect of the development of collaboration, which subsequently creates competitive advantages through collaboration, is to create appropriate tools for managing and measuring this type of development (Verdecho et al., 2009). The empirical part of this study is conducted using two case studies pertaining to industrial collaboration. The article provides insights regarding collaboration in the energy industry, involving four companies, as well as the mining industry, involving three companies.

The challenges that companies face have not been exhaustively studied; thus, it is crucial to understand the factors that characterize the design and implementation process for a PMS in industrial collaboration. In the literature section, the prerequisites and challenges of the PMS design and implementation are thoroughly analyzed, beginning with single companies, continuing with supply chains, and ending with industrial collaborations. In the results and discussion sections, the characteristics of the PMS design and implementation are discussed and compared with previous theory.

This article is structured as follows. First, a review of the literature on traditional performance measurement is conducted, beginning with single organizations and then focusing on supply chains and industrial collaborations. Section 3 describes the research methodology, and the results, in terms of the prerequisites and challenges of a PMS design and implementation in the context of

industrial collaboration, are presented in section 4. The paper concludes with a discussion of the implications of the work and recommendations for further research.

2. Literature review

2.1 *Performance measurement*

Neely et al. (1995) consider performance measurement as the process of quantifying action, where measurement is the process of quantification and action leads to performance. A PMS can be defined as the set of metrics used in this process. Neely et al. (1995) also show that a PMS can be examined at three levels: (1) individual performance measures, (2) a set of performance measures, and (3) the relationship between the PMS and the environment within which the PMS operates. In this study, the second level (performance measures) is the focus, and to some extent, the third level (e.g., customer variety in different industrial collaborations). Bourne et al. (2000) contend that the development of a PMS can be divided into three main phases: (1) the design of the performance measures (designing measures and identifying key objectives), (2) the implementation of the performance measures (in data collection, collation, sorting, and distribution), and (3) the use of the performance measures (for measurement, review, action, and reflection). This study focuses mainly on design and implementation of a PMS. Further, one way to understand how a PMS is designed, implemented, and used is to categorize its key factors to contextualize, process, and understand the measurement content (Pettigrew et al., 1989; Bourne et al., 2002; Cuthbertson and Piotrowicz, 2011; Pekkola and Ukko, 2016). Defining the conditions in which the measurement takes place, how the measurement is carried out, and what is measured are important.

When the barriers of the design phase were discussed, it has been suggested that the measures chosen have been poorly defined (Schneiderman, 1999; Bourne et al., 2002) and that there has been too much focus on financial measures, which has encouraged short-termism and local optimization (Neely et al., 1995; Neely, 1999). This, in turn, has led to a lack of information about what customers want and how competitors perform (Kaplan and Norton 1992; Neely et al., 1995; Neely, 1999). This may result from a lack of strategic focus or actionable vision and strategy, which creates difficulty determining the relative importance of measures and identifying true

drivers (Kaplan and Norton, 1996; Bierbusse and Siesfeld, 1997; Schneiderman, 1999; Bourne et al., 2002). The goals identified in the PMS design process have also been found to be negotiated rather than based on stakeholder requirements, and the large number of measures diluted the overall impact (Bierbusse and Siesfeld, 1997; Schneiderman, 1999; Bourne et al., 2002). Further, the lack of strategy links to department, team, and individual goals has been shown to be a barrier to the design of a successful PMS (Kaplan and Norton, 1996; Bourne et al., 2002; Ukko et al., 2007).

Considering the facilitators of a PMS design, Neely et al. (2000) argue that performance measures should be derived from the company's strategy. The senior management and the senior managers who drive the measurement activities facilitate the design process (Kennerley and Neely, 2002; Bourne, 2005). Everyone, including customers, employees, and managers, should be involved in selecting the measures (Neely et al., 2000; Kennerley and Neely, 2002; Ukko and Pekkola, 2016). Bourne et al. (2000) support this argument and suggest that designing a PMS is principally a cognitive exercise of translating customer views and stakeholder needs into business objectives and appropriate performance measures. Considering the movement from design to implementation, Neely et al. (2000) conclude that the process of designing a measurement system is intellectually challenging, fulfilling, and immensely valuable to managers who participate fully in it. However, the authors caution that increasing anecdotal evidence suggests that the process of designing a measurement system is not the most difficult task. Instead, the real challenges occur once managers have developed their robust measurement system, for then they must implement the measures. As soon as managers seek to do so, they encounter fear, company politics, and subversion (Neely et al., 2000).

The barriers to implementing a PMS include the effort required for the implementation, the ease of data accessibility through information technology (IT) systems, the personal consequences of measurement (Bourne et al., 2002; Bourne, 2005), time-consuming and costly data collection, inflexible IT systems (Bierbusse and Siesfeld; 1997; Bourne et al., 2002; Kennerley and Neely, 2002; Nudurupati and Bititci, 2005), lack of leadership, and resistance to change (Meekings, 1995; Bourne et al., 2002). Overlapping projects can also be a barrier to implementing this system (Bourne et al., 2000). Many factors can help overcome these challenges and facilitate the

implementation of a PMS. For example, integration of the measurement with strategy development and business process review, commitment by senior management, perseverance, and a paternalistic company culture have been found to be facilitators of implementation (Bourne et al., 2002; Kennerley and Neely, 2002; Bourne, 2005). Bourne et al. (2002) showed that in successful companies, a PMS was implemented with the aim of “managing [the] business better,” a higher goal than “improving the measurement system” (Bourne et al., 2002). A paternalistic culture was seen as it reduced the fear of measurement and therefore, resistance to the implementation (Bourne et al., 2002).

2.2 *Performance measurement in supply chains*

Another established stream of literature addresses the process of SCPM from design to implementation. Angerhofer and Angelides (2006) define a collaborative supply chain as “a system of interlinkages and inter-relationships of the stakeholders along with the processes undertaken, its supporting technology and the business strategy employed.” Managing a supply chain requires understanding the inter-organizational management of the flow of goods and related information, which ensures performance and customer achievements for the organizations involved (Hofmann and Locker, 2009). Hofmann and Locker (2009) define SCPM as the collaborative process of quantifying the effectiveness and efficiency of actions in the supply chain, in which effectiveness expresses how well customers’ requirements are met, and efficiency measures how resources are allocated economically within the supply chain when it provides a pre-specified level of customer satisfaction.

The challenges of SCPM are amplified by increased pressure to measure partnership, collaboration, agility, and business excellence requirements (Akyuz and Erkan, 2010). The process for selecting measures for SCPM attention should be guided by organizational goals and objectives, the type of business, the nature of the market, and technological competence (Gunasekaran and Kobu, 2007). This means that SCPM must be developed throughout the supply chain. All participants in the supply chain should be involved and committed to common goals, such as increased customer satisfaction throughout the supply chain and enhanced competitiveness

(Gunasekaran et al., 2004). Thus, SCPM requires a complete and dynamic approach throughout the supply chain based on sound practices (Gunasekaran et al., 2004; Akyuz and Erkan, 2010).

As a response to these challenges, most of the studies related to SCPM discuss what to measure and provide valuable information and guidelines for designing a PMS (Papakiriakopoulos and Pramadari, 2010). Previous research focused on diverse methods of classifying measures (Beamon, 1999; Gunasekaran et al., 2001; Chan, 2003; Gunasekaran et al., 2004; Aramyan et al., 2007), but the common understanding has been that a balanced set of measures should be utilized. Some researchers separate qualitative and quantitative measures (Beamon, 1999; Chan, 2003), whereas others distinguish between measures that focus on strategy, operations, or tactics (Gunasekaran et al., 2001; Gunasekaran et al., 2004; Gunasekaran and Kobu, 2007).

Gunasekaran and Kobu (2007) present that operations-level measurement has received significant attention from researchers and practitioners, but the strategic and tactical levels need more attention due to their significance in supply chains. Similarly, Chelariu et al. (2014) suggested that SCPM focuses primarily on operational and economic performance measures while paying less attention to relational and strategic performance measures. The main obstacle to using such qualitative, forward-looking indicators is the difficulty of quantifying these measures (Aramyan et al., 2007). Challenges to a PMS can also result when the strategy and measurements are not connected, when a biased focus on financial metrics occurs, and when there are too many isolated and incompatible measures or problems in a supply chain system (Gunasekaran and Kobu, 2007). However, the current literature provides examples of the positive effects of aligning strategic goals and performance measurements. For example, Pohl and Förstl (2011) find that a purchasing PMS aligns the purchasing strategy with the segmented-product or service-category strategies.

Other research has highlighted important issues during the implementation of SCPM (Papakiriakopoulos and Pramadari, 2010). Charan et al. (2008) found that awareness of SCPM systems is a very significant driver of implementation. They suggest that senior management should focus on improving the awareness of PMSs in supply chains, encouraging commitment among senior management, ensuring consistency with strategic goals, allocating funding for implementing PMSs, and designing effective information systems. Akyuz and Erkan (2010)

contend that implementation requires considering business process management and technical and organizational/managerial issues simultaneously. In addition to business process management, Papakiriakopoulos and Pramadari (2010) emphasize the importance of collaboration and data management in implementing an SCPM system. They consider collaboration the main driver for implementing a PMS because collaboration is the common objective of all parties although they have their own mechanisms and identify areas to improve in different ways (Papakiriakopoulos and Pramadari, 2010). In addition, collaboration, aided by information sharing, improve the performance of a supply chain (Papakiriakopoulos and Pramadari, 2010; Liang, 2015). The role of a PMS is crucial as it impacts the dynamics between two parties (Nollet et al., 2017). A PMS can assist the collaborating partners in re-evaluating their collaboration objectives, shifting the focus from timely information sharing to enhancing the quality of the information. This then helps the partners re-examine the scope of the collaboration through the incorporation of new business processes (Papakiriakopoulos and Pramadari, 2010).

The second driver of SCPM implementation, data management, includes all the actions performed during the life cycle of shared data (Papakiriakopoulos and Pramadari, 2010). This includes, for example, adequate IT systems. At the operations level, IT systems are especially important in supply chains as the systems are used to link a company to its partners and act as an effective communication infrastructure by assisting in information sharing (Angerhofer and Angelides, 2006; Lu et al., 2006; Papakiriakopoulos and Pramadari, 2010; Liang, 2015). Angerhofer and Angelides (2006) contend that enabling technologies such as IT systems are also important at the management and strategy levels. At the management level, systems can assist in planning and coordination by providing relevant and accurate information in a timely manner. At the strategic level, they can be used to support decision-makers in strategic decisions that have predominantly long-term effects (Angerhofer and Angelides, 2006). Although information sharing is considered crucial in SCPM, Hofmann and Locker (2009) point out that as long as companies consider their suppliers and customers to be opponents rather than partners, the necessary data exchange cannot take place. This point highlights the importance of true collaboration and shared goals.

The third driver of the implementation of SCPM systems, business process management, reflects the business processes that are not part of the collaboration (Papakiriakopoulos and Pramadari,

2010). Although there is a growing body of literature on SCPM systems ranging from design to implementation, case studies that validate theory and extract knowledge regarding the implementation and use of a PMS in a real operating environment are lacking (Papakiriakopoulos and Pramatarı, 2010).

2.3 *Performance measurement in industrial collaboration*

It is commonly accepted that to survive in a competitive environment, companies must collaborate to meet customers' needs more effectively and efficiently (Bititci et al., 2007, 2012). Collaboration can be defined in many ways, but it generally refers to working together for mutual benefit (Huxham, 1996; Parung and Bititci, 2006; Camarinha-Matos et al., 2009). The collaboration question is no longer about whether to collaborate but about the need to understand and select suitable options (Pisano and Verganti, 2008; Bititci et al., 2012). Thus, if companies aim to create and sustain a competitive advantage through collaboration, their collaboration structures should be understood, measured, and managed; otherwise, the objectives will not be achieved, and the collaboration will fail (Verdecho et al., 2009; Pekkola and Ukko, 2016).

It has been suggested that collaborative performance measurement can drive networks to change the focus of network management from contribution and operations to joint strategy and commitment (Kaplan et al., 2010). Papakiriakopoulos and Pramatarı (2010) describe a collaborative PMS as a set of measures used to quantify the efficiency or effectiveness of purposeful joint actions. For example, a collaborative PMS could be used to manage business processes and guide actors to pursue common targets for collaboration (Beamon, 1999; Leseure et al., 2001; Busi and Bititci, 2006; Kulmala and Lönnqvist, 2006). Based on the objective of the collaboration, the measures monitor external relations and the efficiency of internal and extended processes (Busi and Bititci, 2006). Collaboration can also be more structured and mature, with entities sharing information, resources, and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal, thus generating value (Camarinha-Matos et al., 2009). After considering the implications, Mahama (2006) showed that a PMS facilitates cooperation and socialization in inter-organizational relationships and helps ensure that performance information is distributed fairly among the participants, thus facilitating learning and

problem solving within the network. The factors influencing performance management are enterprise collaboration, operations management and business process management/engineering, performance measurement/management and decision support, information and communication management, and organizational behavior and knowledge management (Busi and Bititci, 2006). Busi and Bititci (2006) claim that all of these elements should be analyzed to develop measures for collaborative performance management.

Bititci et al. (2012) emphasize that future research on the design of a collaborative PMS should focus on understanding collaboration and its mechanisms and on developing theories, methods, and techniques to ensure that all network partners can define, manage, measure, and evaluate common goals and responsibilities. A collaborative PMS should be designed to utilize a balanced set of performance measures that monitor external relationships and the efficiency of internal and extended processes, which will support proactive management based on feedback and feed-forward operations control (Busi and Bititci, 2006). Regarding a balanced set of performance measures, Parung and Bititci (2006, 2008) propose numerous value generators in addition to financial assets (e.g., physical assets and human, organizational, and relational capital) because the extant literature and empirical evidence on collaborative performance measurement seem limited to financial measures (Kald and Nilsson, 2000; Leseure et al., 2001; Håkansson and Lind, 2004). The success of a collaboration and its measurement can be examined through the following: (1) the input of each participant in the collaboration, (2) the health of the collaboration, and (3) the outcome of the collaboration (Parung and Bititci, 2008). Measuring the input focuses on the resources the participants contribute to the collaborative network. Assessing the health of a collaborative network entails measuring the dimensions commitment, coordination, trust, quality of communication, and participation, as well as the presence of the conflict resolution technique of joint problem solving (Parung and Bititci, 2006, 2008). Measuring the output determines the benefit accrued to the key stakeholders as a result of their participation in the collaboration. According to Parung and Bititci (2006), the outcome of the organization is usually associated with its performance, and performance measurement is often linked to the efficiency and effectiveness of an organization as it works to satisfy its customers (Neely, 1999). To evaluate the benefits for participants who join collaborative networks, the output should be measured before and after the collaboration (Parung and Bititci, 2006). It has also been found that when designing a PMS,

collaborations face difficulty evaluating and determining the unit of analysis (Beamon, 1999; Busi and Bititci, 2006).

Busi and Bititci (2006) emphasize that the difficulties of developing a collaborative culture and appropriate performance measures have been major barriers to the successful implementation of a collaborative PMS. Thus, determining the key elements of collaboration, the ways in which these elements interact, and the ways in which the elements can be integrated within a PMS is necessary. Radnor and Barnes (2007) contend that in addition to the measurement (which includes reporting and performance management), the actions taken should be considered. Henri (2006) reveals that the effectiveness of a PMS depends on the availability of the right information attributes, as well as how companies use these attributes. Given the dynamics of today's service environment, a more interactive information exchange process based on a broader scope of information is required to identify the right approach for capturing opportunities and positioning businesses (Amir, 2014). Thus, developing a suitable communication infrastructure is necessary. The network must have a clear vision regarding the roles and targets of the network and an understanding of and commitment to the shared objectives.

To overcome these challenges when designing and implementing a collaborative PMS, Ukko et al. (2015) propose that the state of the collaboration, the services provided, and mutual values need to be defined collaboratively before the design process for the actual measures begins. Niebecker et al. (2010) present that the different organizations in collaboration typically define their individual strategies and goals for the collaboration first and then identify and consolidate common strategies and goals with their partner. This method helps prevent misunderstandings and ambiguous shared project goals and common measures. Niebecker et al. (2010) also observe that the partners need to come together to discuss and clarify their common project goals and strategies before the project is in progress. The project partners define common key performance indicators (KPIs) to measure the project targets, and at the same time, the project partners define corrective actions for when the KPIs are not met. Further, the partners need to develop strategy maps. By collaborating, the partners can exchange and synchronize these KPIs without threatening each company's know-how and information protection, as only relevant and predefined indicators are monitored and controlled. Thus, each partner's alignment to business strategies and project goals

can be assured, stakeholder commitment ensured, and measures defined and used collaboratively (Niebecker et al., 2008, 2010). Baines and Lightfoot (2014) emphasize the need to adopt performance measures that reflect outcomes aligned to individual customers, and these performance measures are then disseminated throughout the extended processes of different organizations. Measures at different levels are needed to align operations to serve customers in terms of the outcomes the customers desire (Baines and Lightfoot, 2014).

2.4 *Research framework*

In the literature section, previous studies about the characteristics of a PMS design and implementation were examined beginning with single companies, continuing with supply chains, and ending with industrial collaborations. Next, these characteristics were reanalyzed to create the research framework presented in Table 1. In this table, the characteristics are presented in terms of the prerequisites and challenges, in which the prerequisites are considered drivers of PMS design and implementation, and the challenges are barriers to PMS design and implementation.

Table 1. Overview of current research

Characteristics	References
DESIGN/PREREQUISITES	
- Involving and committing all participants in the supply chain to common goals, such as increased customer satisfaction throughout the supply chain and enhanced competitiveness	Gunasekaran et al., 2004; Hofmann and Locker, 2009
- Increasing senior management participation and commitment, as well as involving customers, employees, and managers in selecting the measures	Neely et al., 2000; Kennerley and Neely, 2002; Bourne, 2005; Ukko and Pekkola, 2016
- Considering the design as a cognitive exercise of translating customer views and stakeholder needs into business objectives and appropriate performance measures	Bourne et al., 2000
- Considering the design intellectually challenging, fulfilling, and immensely valuable to managers who participate fully in it	Neely et al., 2000
- Understanding collaboration and its mechanism for measuring and managing common goals and responsibilities; Understanding of the inter-organizational management of the flow of goods and related information	Hofmann and Locker, 2009; Bititci et al., 2012
- Defining individual strategies and goals first and then identifying and consolidating common strategies and goals with the partners; Discussing and clarifying the common project goals and strategies before the project is in progress	Niebecker et al., 2010; Ukko et al., 2015
- Considering the need for strategic, tactical, and operational measures; A balanced set of measures used to quantify the efficiency or effectiveness of purposeful joint actions	Busi and Bititci, 2006; Papakiriakopoulos and Pramatar, 2010

- Monitoring external relations and the efficiency of internal and extended processes Beamon, 1999; Leseure et al., 2001; Busi and Bititci, 2006; Kulmala and Lönnqvist, 2006
- Including measures at different levels to align operations to serve customers in terms of the outcomes the customers desire Gunasekaran et al., 2004; Hofmann and Locker, 2009; Baines and Lightfoot, 2014

DESIGN/CHALLENGES

- Too many measures and too much focus on financial measures; short-termism and local optimization Neely et al., 1995; Neely, 1999; Schneiderman, 1999; Bourne et al., 2002
- Lack of information about what customers want and how competitors are performing Kaplan and Norton 1992; Neely et al., 1995; Neely, 1999; Kaplan and Norton, 1996
- Lack of strategic focus or actionable vision and strategy; Difficulty identifying true drivers Bierbusse and Siesfeld, 1997; Schneiderman, 1999; Bourne et al., 2002
- Lack of strategy links to department, team, and individual goals Kaplan and Norton, 1996; Bourne et al., 2002; Ukko et al., 2007
- Pressure to measure partnership, collaboration, agility, and business excellence requirements Akyuz and Erkan, 2010
- Difficulty in quantifying future-oriented indicators Aramyan et al., 2007
- Strategy and measurements are not connected; Too many isolated and incompatible measures in a supply chain Gunasekaran and Kobu, 2007
- Collaborations face difficulty evaluating and determining the unit of analysis Beamon, 1999; Busi and Bititci, 2006

IMPLEMENTATION/PREREQUISITES

- Improving the awareness of a PMS, commitment of senior management, allocation of resources for a PMS, perseverance, and paternalistic culture Bourne et al., 2002; Kennerley and Neely, 2002; Bourne, 2005; Charan et al., 2008
- Integrating measurement with strategy development and business process review Bourne et al., 2002; Kennerley and Neely, 2002; Bourne, 2005
- Considering business process management and technical and organizational/managerial issues simultaneously Akyuz and Erkan, 2010
- Re-evaluating collaboration objectives and re-examining the scope of the collaboration through the incorporation of new business processes Papakiriakopoulos and Pramatarı, 2010
- Assuring an effective communication infrastructure that assists in information sharing, high information quality, and timely information sharing Angerhofer and Angelides, 2006; Papakiriakopoulos and Pramatarı, 2010
- Adequate and integrated IT system that links a company with its partners and assists information sharing at the operations level, assists planning and decision-making at the strategy and management levels Angerhofer and Angelides, 2006; Lu et al., 2006; Papakiriakopoulos and Pramatarı, 2010; Liang, 2015
- Understanding the importance of collaboration by determining the key elements of the collaboration Busi and Bititci, 2006; Papakiriakopoulos and Pramatarı, 2010
- Managing data collaboratively with appropriate information attributes and an interactive information exchange Henri, 2006; Papakiriakopoulos and Pramatarı, 2010; Amir, 2014

IMPLEMENTATION/CHALLENGES

- Encountering fear, company politics, and subversion Neely et al., 2002
 - Considering the suppliers and customers opponents rather than partners Hofmann and Locker, 2009
 - Difficulty developing a collaborative culture and appropriate performance measures Busi and Bititci, 2006
 - Effort required for implementation, the personal consequences of measurement, lack of leadership, and resistance to change Meekings, 1995; Bourne et al., 2002; Bourne, 2005
 - Difficulty accessing data through the IT systems, time-consuming and costly data collection, inflexible IT systems Bierbusse and Siesfeld, 1997; Bourne et al., 2002; Kennerley and Neely, 2002; Bourne, 2005; Nudurupati and Bititci, 2005
 - Overlapping projects Bourne et al., 2000
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The research aims to study the characteristics that are considered crucial to designing and implementing a PMS in an industrial collaboration, in which multiple tiers, extending beyond the buyer-supplier dyad, are considered (cf. Maestrini et al., 2017). We consider prerequisites and challenges crucial characteristics that need to be examined in the design and implementation of a PMS. The research questions are as follows:

RQ1. What are the prerequisites and challenges in the design and implementation of a PMS in an industrial collaboration?

RQ2. How can the prerequisites and challenges be managed in the design and implementation of a PMS in an industrial collaboration?

Regarding RQ1 and RQ2, the empirical results of a PMS design and implementation are discussed and compared against the research framework presented in Table 1. The study aims to provide insights into the research gap related to the characteristics of PMS design and implementation in industrial collaboration with multiple tiers beyond the buyer-supplier dyad.

3. Methodology

This article provides insights from two case studies of industrial collaboration. Referring to Yin (2003), one rationale for using case studies is the researcher's access to a situation that was previously inaccessible in the literature; therefore, the descriptive information alone will be revelatory. Because of the nature of the research, the case study was deemed appropriate in terms of the importance of the phenomenon in practice. A case study, which can use various data collection methods, together with a participatory approach to data collection (cf. Maestrini et al., 2016), provides a solid setting for examining the characteristics of PMS design and implementation in industrial collaboration with multiple tiers. In this study, the participatory approach refers to a situation where researchers have assisted the PMS design and implementation process but have not actively participated in decision-making concerning the PMS's content. The research focused on the design and implementation of a PMS and does not examine experiences of using the PMS. Although the design and implementation process was considered successful,

confirmation of this would have required a more extensive period of investigation. This has been a guideline for this study's research strategy.

3.1 Case selection

In Finland, the ongoing global economic transformation is evident in many ways. Due to ever-increasing automation, continuous flow production, and fierce competition, the importance of the usability of industrial facilities is emphasized. Thus, industrial services are becoming increasingly important to the global competitiveness of Finnish industries. This shift has provided companies that had engaged purely in production with the opportunity to implement services alongside production activities. Numerous industrial equipment providers have tried to increase their own business by investing in the development of industrial services. A wide base of installed equipment offers a comprehensive foundation for building a service business. However, many equipment providers still adhere to traditional production, and creating support services has been a challenge for these companies. Due to outsourcing, the number of companies that focus solely on industrial services has increased. These industrial service providers can integrate service packages and offer customers comprehensive service agreements and solutions, both regionally and internationally.

Outsourcing industrial services has spread because companies firmly believe that they achieve added value through new kinds of collaborative operating models. In addition, based on previous research, it seems clear that through the systematic development of collaboration between relevant partners, companies can significantly improve the performance and competitiveness of their overall operation (Papakiriakopoulos and Pramadari, 2010; Liang, 2015). Thus, these types of collaborative industrial entities provide a promising research context. The industrial maintenance context was chosen to study a PMS in an industrial collaboration as many of the global trends (such as the digitalization of industry, outsourcing, and a long-term perspective) affect operations. The companies that operate in maintenance collaborations confront increasingly complex and dynamic interactions, in which factories buy maintenance work from their equipment providers or companies specialized in industrial maintenance that sell service agreements or operating services for industrial plants. Many of the actions related to industrial maintenance are critical in terms of the mutual performance of collaboration, as well as business continuity. For this purpose, there is

a need to study the implementation and design of a PMS, which allows all parties at different tiers of the supply chain to take an active role in the measurement and management process, and enables mutual collaboration in performance. This research area has not been thoroughly investigated thus far (Koufteros et al., 2014; Melnyk et al., 2014; Maestrini et al., 2017; Maestrini et al., 2018).

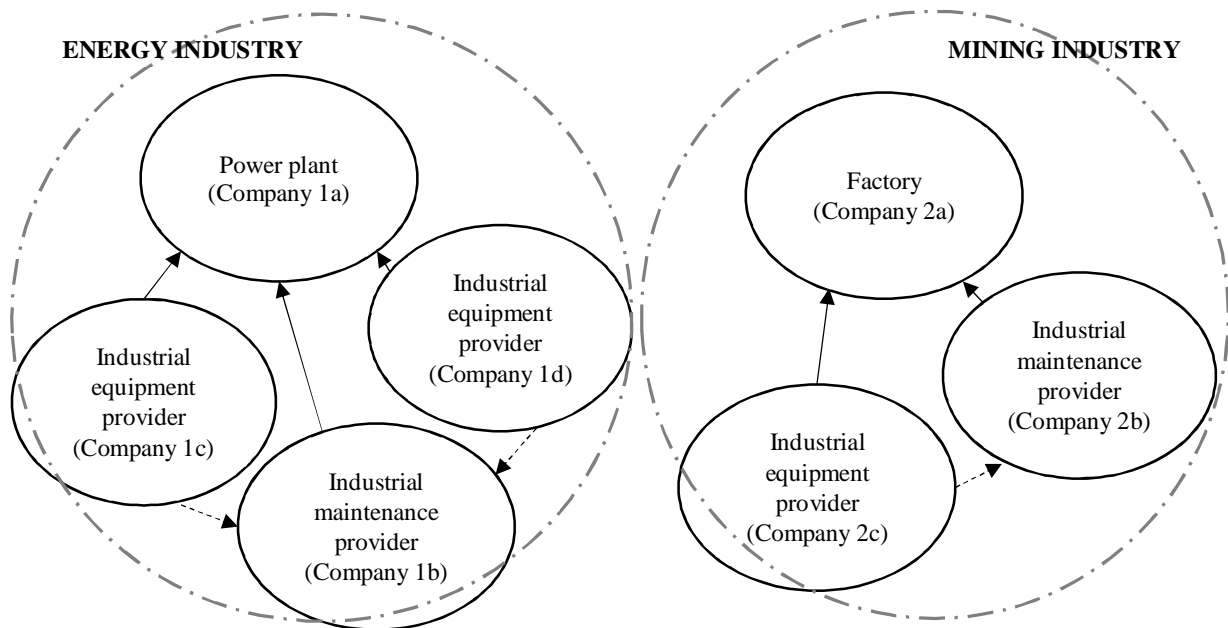


Figure 1. The organization of the companies described in the case studies

Seven companies were used as industrial collaboration cases: four companies in the energy industry and three in the mining industry (Figure 1). Cases were selected based on the level and maturity of industrial collaboration at the companies, because such collaboration plays a crucial role in measuring performance (Busi and Bititci, 2006 Verdecho et al., 2009; Bititci et al., 2012). Therefore, in cases where the need for collaboration is high, it can be reasoned that the design and implementation of PMSs should be emphasized. Furthermore, the cases were chosen from two different industries to analyze prevailing practices across contexts (Yin, 2003). Within each industry, the selected companies played three different roles: as the factory leading the collaboration, as the industrial service provider, and as the industrial equipment provider. The factory collaborates with industrial service providers and with industrial equipment providers. The industrial service provider performs the service in the factory. The industrial equipment provider delivers equipment for the factory's production process. Due to confidentiality, the companies

were labeled according to their industrial entities. Descriptions of the companies and their relationships, as well as the study participants, are presented in Table 2.

Table 2. Overview of the case companies

Company	Description of the company	Description of collaboration between companies	Study participants
Company 1a	Company 1a is a factory that produces electricity and heat and is a large Finnish energy corporation.	Maintenance and operation of the power plant are outsourced almost totally to an external service provider (company 1b). Companies 1c and 1d have supplied equipment to the power plant and are partly responsible for their maintenance.	Plant Manager, New Business Development Manager
Company 1b	Company 1b is a large industrial maintenance and operations services provider.	This company runs the operations and maintenance services of the power plant of company 1a. It has purchased equipment from company 1c and 1d in order to provide maintenance to the power plant.	Head of Expert Services & Business Development, Executive Vice President of Service Agreements
Company 1c	Company 1c is an industrial equipment provider whose main products are industrial pumps and mixers.	This company has supplied equipment to company 1a and is partly responsible for their maintenance. It is a sub-supplier of the power plant through company 1b.	Manager of Service Business, Area Sales Manager
Company 1d	Company 1d is an industrial equipment provider that produces and maintains different types of boilers for industrial facilities.	This company has supplied equipment to company 1a and is partly responsible for their maintenance. It is a sub-supplier of the power plant through company 1b.	Business Area Director
Company 2a	Company 2a is a factory that produces limestone-based products for industry and is part of a larger international corporation.	Factory maintenance is outsourced to company 2b. Specialized maintenance work is supplied by specialized industrial service providers.	Department Manager, COO
Company 2b	Company 2b is a small industrial service provider with few customers.	This company operates in close collaboration with the company 2a factory and takes care of the routine maintenance of the facilities. It has purchased equipment from company 2c in order to provide maintenance to the factory.	CEO, COO
Company 2c	Company 2c is a large industrial equipment supplier that operates in the ore, metal, and energy industries.	This company has supplied equipment to company 2a and is partly responsible for their maintenance. It is a sub-supplier of the factory through company 2b.	Manager - Risk Management, Manager - Service Business, Business Area Controller

3.2 *Data collection and analysis*

To build theory from case studies, detailed observation, triangulation, careful determination of cause-effect chains, and logical inference are required (Meredith, 1998). This guideline was followed throughout the research process. Similar research processes were used for the energy and mining industry cases to ensure scientific transparency and repeatability. The data were gathered between November 2012 and September 2014. The research process included five main phases, in which written assignments, focus groups, and observations were used to collect data. The research phases are presented in Table 3. People from different companies and in different roles participated in the focus groups. To obtain the best possible results for each construct assessed, the participants varied among the focus groups so we could compare viewpoints among companies, as well as among interviewees with various roles regarding industrial collaboration. The data also included written assignments by the representatives of the participating companies, as well as documents and observation diaries from the focus groups. The topics for the focus groups were selected based on the written assignments and an analysis of the previous meeting. Thus, the topics and issues were chosen beforehand (based on the research framework derived from literature), but the discussions were informal and facilitated with supporting questions and comments by the researchers. At the end of the research process, an open-ended survey was utilized to collect additional information. A mix of data collection methods was adopted to increase the validity of the findings. Individual views and opinions of the case company representatives were gathered through pre-assignments before the focus groups and an open-ended survey were conducted at the end of the research process. Focus groups were used as the primary data collection method as they are useful for gathering the opinions of key informants who have a common interest. Focus groups take advantage of group interactions which was considered crucial when studying the characteristics of PMS design and implementation in industrial collaboration.

Researchers conducted the study and then analyzed the data with content analysis (Carley, 1990), after which the researchers discussed the common view. The researchers also adopted theory triangulation. In employing different theoretical frameworks (a PMS in a single organization, supply chains, and industrial collaboration), the goal was to produce new understanding. Although the study belongs to the performance measurement and management research stream, supply chain

and service management research was also used to integrate existing theory with new contexts. In addition to case-specific analyses, cross-case analyses were conducted. The analyses were conducted at the levels of industrial collaboration and individual organizations. The analysis was informed by the research framework presented in section 2.4. As the goal of the study was not to achieve scientific generalization, theoretical concepts of the research framework were used for themes in the analysis (Yin, 2003). Thus, the data analysis was guided by the prerequisites and challenges of PMS design and implementation presented in the research framework (Table 1).

Table 3. Content of the collected data

Phase	References	Data gathering	Type of data	Data analysis
Culture and contextual factors Vision and mission	Bourne et al., 2000, 2002; Cuthbertson and Piotrowicz, 2011; Pekkola and Ukko, 2016	Pre-assignment Focus group (9 participants) Observations in the focus group	16 written pre-assignments 4 written reports of focus groups 2 observation diaries	Content analysis of - written pre-assignments - written reports - observation diaries
Organization structure Strategies and plans	Neely, 1999; Neely et al., 2000; Niebecker et al., 2010	2 focus groups 1) 5 participants (from 4 energy industry companies) 2) 3 participants (from 2 mining industry companies) Observations in the focus groups	2 written reports of focus groups 2 observation diaries	Content analysis of - written reports - observation diaries
Key success factors	Neely et al., 1995; Neely, 1999; Gunasekaran and Kobu, 2007	Pre-assignments 2 focus groups 1) 5 participants (from 4 energy industry companies) 2) 3 participants (from 2 mining industry companies) Observations in the focus groups	4 written pre-assignments 2 written reports of focus groups 2 observation diaries	Content analysis of - written pre-assignments - written reports - observation diaries
Key performance measures Target setting	Neely et al., 1995; Neely, 1999; Gunasekaran and Kobu, 2007	2 focus groups 1) 4 participants (from 3 energy industry companies) 2) 3 participants (from 3 mining industry companies) Observations in the focus groups	2 written reports of focus groups 2 observation diaries	Content analysis of - written reports - observation diaries
Performance evaluation Implementation	Bourne et al., 2000, 2002; Busi and Bititci, 2006; Parung and Bititci, 2008	Focus group (6 participants) Observations in the focus group Open-ended survey	1 written report of focus group 1 observation diary Written survey responses	Content analysis of - written report - observation diary - open-ended survey responses

4. Results

In this section, the prerequisites and challenges of designing and implementing a PMS for industrial collaboration are presented and analyzed. Table 4 presents the main features of the PMSs in the investigated industrial collaborations.

Table 4. Main features of the PMSs

	Energy case	Mining case
How the PMS was designed and implemented	Designed collaboratively during focus groups, Implemented under the leadership of the power plant and the industrial maintenance provider	Designed collaboratively during focus groups, Implemented under the leadership of the factory and the industrial maintenance provider
Who designed the PMS	Collaboratively between industrial entity members	Collaboratively between industrial entity members
What type of KPIs were included	Safety (compliance with work safety policies, compliance with environmental safety policies, recycling of materials) Quality (provider reviews, reputation, know-how, energy efficiency, predictive/corrective maintenance service) Reliability (timely execution of the maintenance work, timely deliveries, flexibility in hurdles, speed and quality of service, compliance of the maintenance work as promised, functioning of the target of the maintenance work) Cooperation (contract duration, management commitment) Finances (costs, price compared to the received service) Customer value/satisfaction	Safety (compliance with work safety policies, compliance with environmental safety policies) Quality (maintenance outcome compared to planned and agreement, maintenance outcome is sustained for the promised time, information provision related to equipment/production process) Reliability (timely execution of the maintenance work, compliance of the maintenance work as promised, functioning of the target of the maintenance work, reclamations) Cooperation (information exchange, compliance of agreement (service warranty and terms of payment), service attitude) Finances (costs, price compared to the received service) Customer value/satisfaction
Who manages the PMS	Under the leadership of the power plant	Under the leadership of the factory
Who collects data and calculates the KPIs	Power plant as responsible, Each company on its own perspective	Factory as responsible, Each company on its own perspective
How is information shared among the partners	Collaboratively formed action plan for the next year, shared with partners Meetings in which actions are reviewed (are actions working as planned, are costs within budget, etc.)	Informal meeting once a year, Discussions as soon as problems occur (verbally but also documented and shared with the partner)

4.1 Prerequisites for PMS design in industrial collaboration

When focusing on the design of a PMS in an industrial collaboration, the various actors and their roles in the industrial entity must be defined. In an energy case, the main actor provides services

and products to the end customer (in this case, end customer refers to the consumer or company that buys electricity from the plant) and to the other actors in the value chain that provide services and equipment to the main actor. Throughout the research process, it became apparent that the strategic alignment of the whole entity was considered important, including responsibilities within the entity. The roles and responsibilities of the different actors need to be defined, because to benefit a PMS within the context of industrial collaboration a systematic approach to the management of the industrial entity was required. A focus group participant from the energy case stated the importance of clearly defined responsibilities:

Who will lead this [collaborative] entity? In this way, it is possible to get the individual actors to really work together to achieve the same common goal.

A systematic approach to managing the entire entity [is needed] in order to see how the whole [entity] works and focus on improving the right things.

This requires bringing partners together to discuss and clarify their common strategies and project goals before the PMS project is in progress. From the viewpoint of the design phase of performance measurement, the maturity of the collaboration is sufficient only when the collaboration between the actors is considered strategic. For the collaboration to be considered strategic, the collaborative entity needs a mutual vision, strategy, and targets. The PMS design process, which was conducted during the focus group meetings, was considered one means of deepening the collaboration and increasing the motivation to work toward a common goal and communication within the industrial entity.

With respect to roles and responsibilities, the dynamics of the collaboration were considered to play a big role in designing the PMS. Thus, the development of a collaborative culture was perceived to be important in the case study collaborations. This type of culture could increase the flexibility of the collaboration, but it was also considered highly dependent on the individual PMS project participants. In the focus group discussions, trust between the actors, as well as the continuity of the collaboration, was perceived as crucial during the design phase.

Another prerequisite for collaborative PMS design is the specification of the total value of the collaboration, which was highlighted in both cases. Specification includes identifying the value

elements and how they should be managed. During the focus groups, the participants agreed that shared processes and resources should be more efficient and that the processes of other actors within the entity should also be better understood. The collaborative partners need to operate together as a unit—not as separate actors with individual targets. Operating together requires seeking mutual benefit and commitment from all partners involved. Within the mining entity, the main reason for developing a measurement for the collaborative performance was to better manage the end customer (in this case, end customer refers to a company that buys the plant's products) interface. The end customers wanted to do business through one specified contact. Further, the main characteristics for the performance measurement of a mining entity was connected to the vast variety of end customers. The common opinion was that before measurement is implemented, customers need to be segmented to offer targeted services depending, for example, on how critical the service is for the customer. Because different customer segments found different issues in service delivery to be important, different measures for each customer segment were needed. The need to consider the end customer interface was highlighted in the comment of a mining company manager: “Different issues are important to different segments—thus, different measures depending on the criticality of the process.”

When focusing on the performance measurement of industrial collaboration, developing a measurement that covers the nested processes of different actors within the collaboration and the individual processes within the entire entity is necessary. In this way, it is possible to simultaneously measure the extended processes of the industrial entity and to ensure their effectiveness. Traditionally, the case study organizations measured their own practices as part of their extended processes for industrial collaboration. However, this approach eventually led to discontinuities and a situation in which the different partners' processes were measured separately. The focus group participants agreed that the processes of the individual actors must have their own measures, which should be linked to the measures for the entire entity. This approach can be advanced by utilizing strategy maps. The results for the measures related to the individual actors' processes should be in line with the results for the measures for the entire entity and its extended processes. The focus group participants from both cases acknowledged the importance of linking these measures to the strategy-level measures of the individual companies. Managers from the

energy companies, who participated in the focus groups, clarified the role of the different types of measurement as follows:

Upper-level targets and measures must be defined first ... and then the measures for individual actors. Monitoring from individual teams to the entire entity must be able to trace the link from the bottom up.

There are two types of measures: key measures and supportive measures that act as an input for the key measures ... Measures must be able to be changed according to the situation.

4.2 *Prerequisites for PMS implementation in industrial collaboration*

Integrating processes of the industrial entity is necessary during the design phase, which is similar to integrating information systems during the implementation phase. Strategic collaboration requires that individual organizations' processes be integrated with those of the other organizations. A collaborative entity, such as the case study entities, includes clearly defined extended processes, common information systems, and the information systems of individual partners. Synchronization of these systems and data transmission are necessary in order to measure and manage the integrated processes of the entire entity. In the case industrial entities, the definition and a shared understanding of common rules for measuring and managing an industrial entity with the commitment of all organizational levels were considered important. The role of information systems in building this understanding was stated by the manager of the energy case: “[One must] take into account the common systems throughout the [collaborative] entity: systems managed by different parties, synchronization systems, and data transmission.”

Among the mining companies, the implementation process of a collaboration-level PMS was considered as important as the measurement itself. The PMS must be implemented at different organizational levels. The measurement of the mutual processes of the different organizational levels should be systematic, and the decisions must be based on the measurement information. Lack of understanding of the purpose of the measurement at a different organizational level of an industrial entity may lead to unsuccessful utilization of the measurement. This type of behavior is difficult to change afterward. The department manager of a company operating in the mining case

company stated: “If you cannot explain to staff why and for what it [the measurement] is used, it can lead to poor provision of data; poor provision of data is more useless than no data at all.”

The guiding effect of the PMS was highlighted in both cases. During the implementation phase, critically assessing that the right measures have been selected and ensuring that these measures are actively used to manage the collaboration are necessary. The focus group discussions highlighted that one of the actors must be responsible for managing and measuring the level of industrial collaboration. This was viewed as a means of ensuring the continuity and increasing the manageability of the collaboration. The focus groups concluded that the measures should be changed when necessary (e.g., when the collaboration develops).

The actors in the industrial collaboration believed that the measurement would solve many problems in service production. The proper PMS would increase collaboration and communication among the different actors. Discussion about the measurement information can take place before, during, and after the service is delivered. The PMS enables mutual targets, which, in turn, helps with the development of rules concerning the actions of different actors in the industrial entity. The importance of mutual understanding of the terms of collaboration and the role of measurement in collaboration was clarified by a mining representative: “The supplier and the client must be more in co-operation than currently is [the case]; that means discussing before, during, and after the work is done.”

4.3 *Challenges of PMS design in industrial collaboration*

The main challenges concerning the PMS design of an industrial collaboration are linked to understanding the level of collaboration. The common opinion was that the collaboration between the actors was strategic and that this direction would continue. The main issue concerning the collaboration was the level of integration of the processes of different actors. If the processes of different actors were not integrated with other actors within an entity and its processes, seeing the strategic elements of the industrial collaboration became difficult.

Through the collaboration-level vision and targets, it is possible to define the value provided by different actors. However, this definition is not sufficient without a clear determination of the roles and responsibilities of different actors. It was stated that one of the actors must play an instrumental role in managing and measuring an instance of industrial collaboration. Even if the strategy and processes of an industrial entity are defined and are in line with those of the upper-level actors, the major challenge is to transmit the same understanding and thinking to the operations level of the entity. A significant amount of openness is needed when calculating, for example, the costs and benefits of the actors' integrated processes. Openness can be advanced by creating proper information channels for communicating mutual benefits and targets. An energy company manager stated:

Functionality requires a commitment of each member [of the industrial entity]; each cannot think of just one's own margin, but rather a common benefit, something for everyone.

[This] requires internalizing the ways of action and commitment in all organizations and at all levels of the organizations.

4.4 *Challenges of PMS implementation in industrial collaboration*

Regarding PMS implementation, it is important to systematically measure the mutual extended processes of the entity's different organizational levels. In the study, a common perception among the actors was that the decisions should be based on collaboration-level measurement information in order to understand the decisions and the results. The challenge is that many actors also use several measures for their own businesses, and there is a risk of confusing these measures with the collaboration-level measures. The challenge for managers lies in ensuring that individual actors' measures are in line with the collaboration-level measures. The challenge of implementing proper measures for different phases and purposes was highlighted by an energy company participant: "The most important thing is to choose the right measures/dimensions and then to ensure their active management." "Follow-up is the most critical phase; this ensures that the measures are correct and develop better." In this regard, integrating information systems and developing data were considered challenging. Thus, integrating information systems requires collaboration throughout the industrial entity at the strategic level, and mutual benefits must be clearly defined.

Although interlinked processes was one of the key themes in the focus groups on PMS design, the reflections of the last focus group and its open-ended survey confirmed that interlinked processes, with respect to information system integration and process coordination, determine the success of the implementation phase. To be truly beneficial for all actors involved in an industrial collaboration, integrating the information systems and data development thoroughly is vital.

The results also indicate that the implementation process of a PMS is challenging when the entity needs to deliver different value elements through services depending on the type of customer. Thus, the variety of services conducted for customers was considered one of the main challenges of implementing a PMS. The different customer services included different value elements. This means the actors in an industrial entity also provided different additional value for the different service processes. This was seen as a challenge because the measures of the service processes for a certain customer segment must be implemented separately, as one part of the PMS of an entire entity.

4.5 *Cross-case analysis and summary of the results*

In this section, the prerequisites and challenges of PMS design and implementation in industrial collaboration are presented, and then the perceived differences are identified and analyzed. A summary of the main findings is presented in Table 5. The results emerged through three major themes, which have been titled as key characteristics in Table 5. Based on the analysis, three central issues characterize the design and implementation of a PMS in the context of industrial collaboration: 1) the importance of collaboration, 2) the importance of coordination and integrated information systems within the system implementation, and 3) the importance of acknowledging the impact of varied customer needs. These characteristics can be considered prerequisites or challenges, and they contain aspects that have been explored and grouped in accordance with the research framework presented in Section 2.4 (design and implementation). Although many of the characteristics of the design and implementation phases overlap, the emphasized phase is noted in the table. These characteristics will be briefly introduced here and discussed in relation to previous studies and in relation to the research framework in the discussion and conclusions section.

Table 5. Summary of the results

Key characteristics	Aspects illuminated	
	Design	Implementation
Importance of collaboration	<p>Better management of the end-customer interface</p> <ul style="list-style-type: none"> - This is the main purpose of collaboration <p>Strategic alignment for collaboration</p> <ul style="list-style-type: none"> - A systematic approach for management that involves the commitment of senior management and responsibilities <p>Worth effort</p> <ul style="list-style-type: none"> - The total value of the collaboration versus the contribution of each partner is calculated 	<p>Collaboration culture</p> <ul style="list-style-type: none"> - Collaboration operators are viewed as real partners rather than opponents
Importance of process coordination and ICT systems-integration within the system implementation	<p>Definition of extended processes</p> <ul style="list-style-type: none"> - A full understanding of which processes are involved in the collaboration and which are not 	<p>Awareness of the collaborative PMS</p> <ul style="list-style-type: none"> - Informing different organizational levels about the extended processes and the new PMS <p>Implementation of extended processes</p> <ul style="list-style-type: none"> - Is as important as performance measurement - Needs to be implemented before the measurement efforts are implemented <p>Discussion about the extended processes and measurement information</p> <ul style="list-style-type: none"> - Should be carried out before, during, and after the service is delivered - Focus on business improvement rather than performance measurement - Integrate information systems after considering the extended processes - Without the common information system, the benefits of the extended processes will not be achieved
Importance of acknowledging the impact of customer needs in terms of variety	<p>Customer segmentation</p> <ul style="list-style-type: none"> - The variety of customers affects the design of a PMS - Different measures should be implemented for different customers - Value provided by different partners depends on the customer segment 	<p>Customer involvement in performance measurement</p> <ul style="list-style-type: none"> - Providing information about their operating environment - Being critical of the delivered service and product

With respect to the design phase, the PMS for an industrial collaboration case with multiple actors was considered to be too convoluted without strategic collaboration. Without a clear vision and targets for co-operation, integrating the service processes and information systems was considered

too laborious and expensive. For this reason, bringing partners together to discuss and clarify their common strategies and project goals before the project is in progress was perceived as very important.

Furthermore, regarding the implementation phase, it was perceived that, without the integration of processes and information systems, the measurement of industrial collaboration would be too shallow and would not correspond to its purpose. To better manage this integration, the development of a collaborative culture was perceived to be significant in the case study collaborations, especially during the implementation phase. During this phase, the importance of understanding the impact of customer needs in terms of their variety was also perceived as crucial. This means, for example, acknowledging how critical a delivered service or product is to a specific customer.

The primary difference between the energy and mining collaborations was the nature of the customer companies. For instance, the energy entity had more homogenous customers, while the mining entity had customers with various needs for various services. This factor was realized in the form of various measures for the different customers within the mining entity's collaboration. As a result, the PMS must be implemented more thoroughly throughout the various organizational levels of an industrial collaboration. In the study, the value provided by different actors within the mining collaboration also depended on the type of customer. In addition, the value provided by an individual actor could change, depending on the type of customer. In the energy collaboration, the value provided by the actors for certain service processes was more stable, regardless of the type of customer.

5. Discussion and conclusions

This study focused on the research gap in the design and implementation of a PMS for industrial collaboration. The setting is a multitier collaboration, where all parties intend to take an active role in the measurement and management process and enable mutual collaboration in performance. This study provides several contributions to SCM literature. It deals with the management of industrial collaboration and, more specifically, the design and implementation of a PMS for

industrial collaboration, in which multiple tiers, extending beyond the buyer-supplier dyad, are considered. Specifically, the study provides novel results regarding (1) the current limitations of literature focused on the PMS design phase by identifying the crucial characteristics that should be examined in both the design and implementation of a PMS, and (2) the lack of an empirical analysis by considering multiple tiers, extending beyond the buyer-supplier dyad, and configuring a multitier SCPMS.

5.1 Theoretical implications

As the primary contribution to this field of study, three main factors that characterize the design and implementation of a PMS in an industrial-collaboration context emerged: 1) the importance of collaboration, 2) the importance of coordinated and integrated information systems within the system implementation, and 3) the importance of acknowledging the impact of varied customer needs.

First, PMS design and implementation need a strong collaborative relationship, beyond the buyer-supplier dyad. The study reveals that PMS design and implementation need to target the management of the end-customer interface. Thus, the results contribute to the neglected topic of multitier collaboration (Maestrini et al., 2017). The necessary level of collaboration is realized by building a strategic-alignment process for collaboration (Niebecker et al., 2010; Ukko et al., 2015) and building value for each partner beyond that of invested resources (Camarinha-Matos et al., 2009; Bititci et al., 2012). Collaborative culture is required in the design and implementation of a PMS (Busi and Bititci, 2006); a PMS in itself does not provide adequate, mutual benefit for industrial collaboration. The design, implementation, and further use create value. Gaining this advantage throughout the process requires the collaboration to be among multiple tiers and at an appropriate level.

Second, industrial collaboration needs a rigorous coordination of processes and integrations of ICT systems in order for PMS design and implementation to succeed. This means defining and understanding the processes that are involved in the collaboration, as well as implementing these processes (Angerhofer and Angelides, 2006; Hofmann and Locker, 2009). PMS implementation

in an industrial-collaboration context requires considerations of business process-management and managerial and technical issues (Akyuz and Erkan, 2010). In addition to business-process management, data management is also crucial (Papakiriakopoulos and Pramadari, 2010). Thus, the study strongly supports the view that ICT systems are especially important in a collaborative PMS, as they link a company to its partners and provide an effective communication infrastructure by assisting in the sharing of information (Angerhofer and Angelides, 2006; Lu et al., 2006; Papakiriakopoulos and Pramadari, 2010; Liang, 2015). This also promotes the awareness of the collaborative nature of PMS implementation, perceived as crucial among the actors in different tiers of the supply chain (Charan et al., 2008).

Third, in the design and implementation of a PMS for industrial collaboration, acknowledging the impact of various customer needs is crucial: Performance measures that reflect outcomes aligned to individual customers must be adopted, and these performance measures should then be used in the extended processes of different organizations (Baines and Lightfoot, 2014). This indicates that customers need to be segmented so that companies can offer targeted services, depending, for example, on how critical the service is for the customer (Pohl and Förstl, 2011; Ukko and Pekkola, 2016). Measures within the different tiers of industrial collaboration are required in order to align operations and serve customers in terms of the desired outcomes of the customers (Gunasekaran et al., 2004; Hofmann and Locker, 2009; Baines and Lightfoot, 2014). For these measures to be implemented, information about customers' operating environments, their specific needs and desires, as well as their participation in evaluating the delivered products and services, are required (Neely et al., 2000; Kennerley and Neely, 2002; Bititci et al., 2012; Ukko and Pekkola, 2016).

5.2 Managerial implications

In terms of managerial implications, the study results suggest that actors in industrial collaborations should carefully consider the state of the collaboration before starting the design process for the PMS. It is important to spread awareness of the end-customer interface across multiple supply-chain tiers and discuss shared measures between different tiers with regard to the end customer. Defining common goals and extended processes and developing compatible information systems are essential to provide a solid foundation for developing the PMS. In

addition, the case examples described here can help practitioners avoid pitfalls when designing and implementing a PMS in a multitier industrial supply chain. The study results assist practitioners in this task by showing what factors are emphasized in an industrial collaboration that seeks mutual collaboration in performance.

5.3 Limitations and future research

As a limitation, the findings of this study are based on data from only two cases, which limits the manner in which the results might be generalized. However, due to the nature of the research subject, an in-depth case study is an appropriate research strategy for gaining a deeper understanding of the design and implementation of a PMS for industrial collaboration. This study showed that more in-depth action research and case studies are needed to validate the results in terms of suitability, usefulness, and acceptability. There are other potential limitations concerning the data collection methods, as well as those usually associated with case studies. To minimize these issues, four researchers gathered the data and analyzed them using content analysis, after which the common view was discussed. Theory triangulation was also adopted. By employing different theoretical frameworks, the goal was to produce new understandings.

Concerning future research, more case studies on different types of industrial collaboration should be conducted to generalize the findings. For example, an understanding of what elements are emphasized in a successful design and implementation process for a PMS for different types of industrial collaboration would be beneficial for academics and practitioners. It is also essential to study measures that have been successfully implemented in practice.

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