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Review

Review of supply chain management within project management

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ABSTRACT

Supply chain management (SCM) adoption in a project-based environment brings substantial benefits but requires careful planning and execution. The current research examines a number of publications that are relevant to both SCM and project management in project management journals. First, we identify the key antecedents of successful SCM implementation in a project-based environment. Then we category these factors into four main areas, namely, IT integration, organizational coordination, risk management, and supply chain resilience and complexity. Third, we explore inter-relationships among these factors through a comprehensive literature review. A broad and enhanced understanding of the conceptual integration of SCM with project management is provided by exploring application areas outside the more common integration domain of the construction industry. This research presents and interprets this integration using a systemigram that visually illustrates a SCM strategy adoption pathway and depicts the complex procedures in an understandable manner.

1. Introduction

The increasing focus of all industries on the supply chain suggests that the consideration of supply chain management (SCM) as applied within projects is of strategic importance to an organization's success (Aloini et al., 2015; Giunipero et al., 2006). Both SCM and project management have drawn increasing attention in the last two decades and resulted in considerable publication in both fields (Ika, 2009; Lambert and Cooper, 2000; Mentzer et al., 2001; Munns and Bjeirmi, 1996; Pich et al., 2002; Ponomarov and Holcomb, 2009). However, little research addresses the theoretical integration of SCM in project management. The current research examines that gap in this emerging area of research because project managers can benefit from better understanding of how to integrate supply chain management within project management when the supply chain is relevant to the project. As projects grow in complexity, the likelihood that they involve a diverse set of experts and applications increases (Maylor et al., 2008; Tatikonda and Rosenthal, 2000). BMW Chief Information Officer Mr. Straub claimed that creating teams that combine technical expertise in a manner that aligns with business strategy is critical to success (Loten and Castellanos, 2019). Business practices benefit from a project-based approach because such an approach reduces management dependency, enhances resource utilization, provides senior management visibility, improves communication, and, as suggested by Straub, better aligns projects with business strategies and goals (Lycett et al., 2004). The scale of a project can range from multi-organizational collaborations to one person with a small budget. For example, the Internet of Things (IoT) is an emerging area where many companies are investing in R&D projects. In the automobile industry, implementing the project of IoT and relevant hardware-software integrations requires collaboration among multiple divisions. Those implementations become particularly challenging when different original-equipment manufacturers and numerous production processes are involved (Loten and Castellanos, 2019).

The project management and supply chain management fields have overlapping research streams, such as risk management (de Araújo Lima et al., 2020). But the possible conjunction of both fields is largely ignored. For a project that involves different suppliers and collaboration among multiple parties, implementing SCM related strategies creates values and improves project performance. However, it is often difficult for project managers to realize those potential benefits in the beginning stage of a project, build a holistic understanding of the integration at the conceptual level, and employ suitable SCM related techniques and strategies. To assist in dealing with the increasing complexity within and across organizations, the current study looks into both project management and SCM and how they are potentially integrated to improve outcomes. Aloini et al. (2015) conducted a pilot study on the SCM adoption in a project-based environment. That research identified 16 antecedents and proposed an SCM adoption path that leads to a

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successful SCM implementation. However, their proposed model was based on semi-structured interviews with the experts in the Yacht-building industry. The causal relationships between those antecedents were not generalized to other project-based cases in similar industries, nor were the critical antecedents elaborated on their interactions with the entire conceptual model. Following the calls from the author, the current study takes a systematic view of the SCM implementation in the project-based environment. In this context, the term systematic view refers directly to the use of visual aids to illustrate the steps of integrating SCM with project management. Fig. 1 below shows the steps defined by Aloini et al. (2015) in a structural format that is required to make the diagram.

The current study investigates the inter-relationships among the critical antecedents of SCM implementation to the project-based industries and explores the high-level process of initiation. Employing systemigram, which is discussed in the next section, enables us to transform "rich text" from the comprehensive literature review into a structured diagram and present findings in a narrative manner. This is the first attempt to visually show the role of SCM related to project management. The contribution is tri-fold. First, in this research, the diagram of the structural model shown in Fig. 1 is further extended by distilling lengthy documentation down to "concentrated text" through the systemigram design to show how SCM is relevant to many applications in the project management. To make this case, the systemigram is defined, and a literature review about the role of SCM to project management is conducted. The development of this research presents a novel method of how to design a systemigram for the system of interest, make a complex system understandable, as well as retain the critical information and key perspectives.

Second, this is the first application of the systemigram to illustrate the integration of SCM with project management. This theoretical integration was illustrated by creating a systematic view of initiating the implementation of SCM in the project. The clarity gained from examining and diagraming the integration resulted in knowledge codification by highlighting the key antecedents and the relationships between each element. The value of such visualization is significant because it emphasizes the importance of the knowledge that is complementary to the existing project management body of knowledge (PMBOK) areas (Project Management Institute, 2017).

Third, from the explanation of each scene, the illustration of interrelationship between those steps, and the presentation of the holistic systemigram, project managers will better understand the role of SCM and the initiating process of integrating SCM into projects. A comprehensive list of references supplied in this study provides a good resource for project managers designing context-specific strategies. Detailed practical contributions are discussed later in this research.

The structure of this manuscript is as follows. First, the Boardman Soft Systems Methodology (BSSM) is described along with how it will allow better illustrating the relationship between SCM and project management. Following that section, the review methodology on the role of SCM in project management is presented. Then, the systemigram model is developed in five steps as termed scenes. These scenes are integrated to provide the systemigram which is examined and explained to provide a better understanding of the crucial steps in the process. Finally, conclusions about the value of the systemigram, practical implications, project limitations, and future research suggestions are presented.

2. Boardman Soft Systems Methodology and systemigram

The soft system methodology (SSM) derived from soft system thinking helps people to address messy management problems because the approach enhances the understanding of the problem situation and allows better complexity management (Checkland, 1989, 2000). For example, SSM was adopted to understand the supply chain coordination in the context of engineer-to-order and outline opportunities for

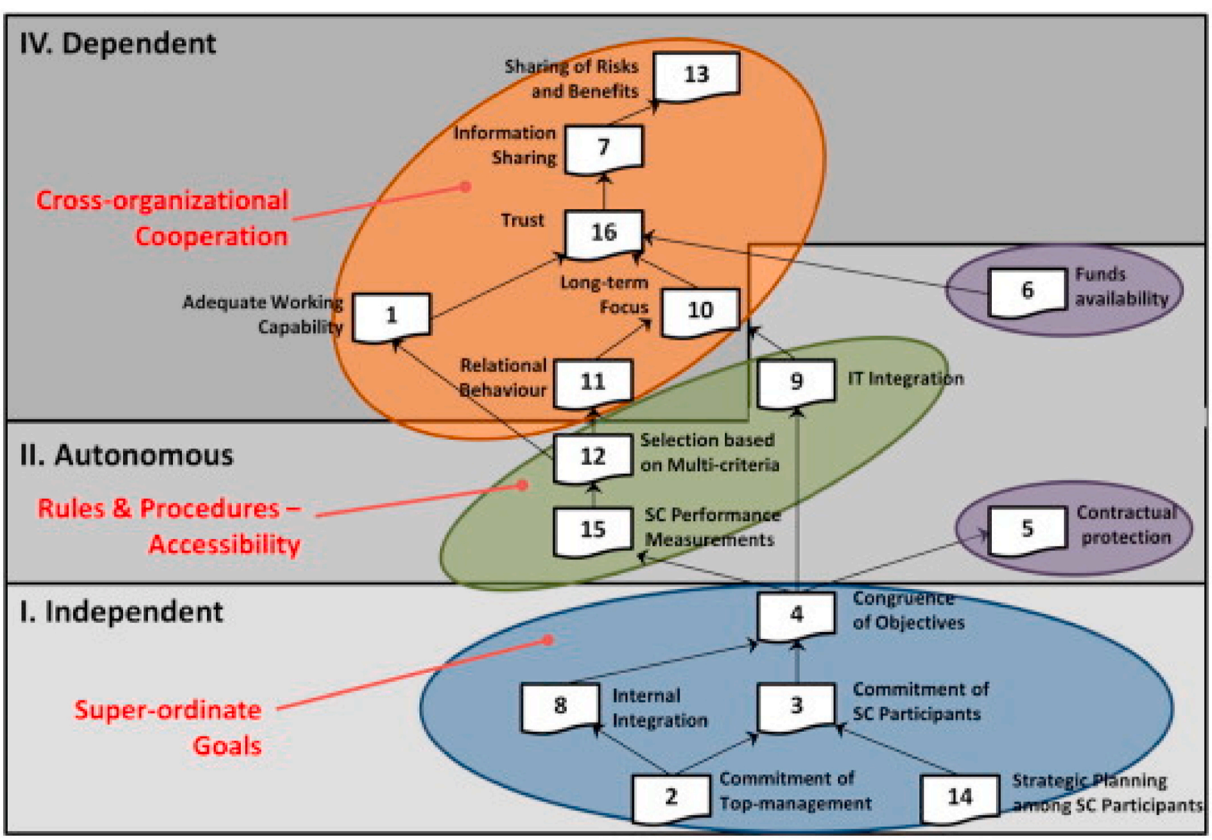

Fig. 1. Structural model of SCM antecedents proposed by Aloini et al. (2015). Reprint permission obtained from Elsevier.

improvement (Mello et al., 2017). Developed based on the SSM, the Boardman Soft Systems Methodology (BSSM) models better human activity systems by using natural language and pictorial representation. To realize this goal, systemigram is utilized. Systemigram is both a system and a diagram that together depict a complex system for easier understanding (Boardman and Sauser, 2013). A regular diagram consists of two main elements: nodes and links. Systemigram, derived from Boardman Soft Systems Methodology (BSSM), integrates a third element: text. To this saying, a well-mapped systemigram and the successful use of it tell a story through a beginning to an end, nodes and links in between, and the logic of the flow. Viewing a systemigram in segments likes watching a movie with different scenes. The compilation of all of the scenes tells a complete story. The enhanced expressive ability to tell a complete story using systemigram makes it a valuable tool for documenting multi-shareholder perspectives and identifying principle perspectives in a system of interest for a researcher. On the one hand, systemigram is designed to present the key concepts at a high level by decomposing a model into scenes. On the other hand, it is also able to reveal the original conceptual thinking through storyboarding. The graphical presentation of a systemigram overcomes the limitation of linear text reading, thus helps to generate new ideas while eliciting inputs from all shareholders (Boardman, 1994; Patrick Eigbe et al., 2010).

The current study investigates the role of SCM in a project-based environment and strategies to implement SCM integration into a project. Because of supply chain complexity and differences between projects across industries, utilizing a systemigram enables this study to provide a holistic view of the high-level conceptual integration. Such benefits are not easily achieved by other concept-capturing diagrams, such as flow charts, influence diagrams, fishbone diagrams, or concept mapping, because they are more memoryless with a focus on the immediacy of prose that diminishes longer thinking threads (Blair et al., 2007). The reliability of the qualitative synthesis and systemigram design is supported with the systematic literature review and extraction of key elements along with their interrelationship from the extant literature.

For researcher and practitioner, using systemigram enables them to capture the reason about a problem, understand the complexity of a problem, and explain the problem to others from a multi-stakeholder perspective. The following outlines the general rules that should be followed while designing a systemigram:

1. Mainstay is the primary sentence in a systemigram that supports the purpose of the system or what the system is. It serves as the anchor for the entire visualization and is read from top left to bottom right of the complete diagram. The beginning of mainstay (first node) indicates the system of interest. The last node represents the goal or objective of such a system.
2. Besides mainstay, other segments, so-called scenes, flow out of and back into the mainstay and connect as needed with their landmark noun phrase nodes.
3. There exists structure in every system, and those structures are made up of parts (nodes) and relationships (links) in a systemigram. The nodes are represented by nouns and noun phrases, whereas the links are represented by verbs and verb phrases.
4. Some nodes, so-called containment node, can contain multiple nodes. However, a node should not be repetitive. Redundant nodes undermine the essence of relationships and may cause confusion.
5. Links should not crossover. This follows the observance of heuristic system design and ensures the systemigram cleaner to view.
6. Finally and ideally, a systemigram should have between 15 and 25 nodes. Fewer nodes make a system description trivial. Many more nodes can create clutter and illegibility.

Overall, a well-designed and meaningful systemigram should consist of fidelity, emphasis, insight, and value-added.

A number of studies have employed systemigram in various applications in appreciation of its effectiveness and comprehension. Some examples include supporting cultural reformation and process improvement (Sherman et al., 1996), manufacturing process improvement (Boardman and Cole, 1996), developing enterprise resilience by mapping the small vessel security strategy (Sauser et al., 2011), improving systems engineering (Cloutier et al., 2014), exploring and mapping influencing factors of eHealth marketing for millennial (Prybutok et al., 2017) as well as recovery from service failure (Harun et al., 2018).

3. Review methodology

This work focuses on SCM and project management research within the business discipline. Consistent with that focus we relied on a relatively comprehensive list of business journals, the Australian Business Deans Council (ABDC) list, to identify the target journals. First, we searched the keyword "project" in the journal list and found six journals with the keyword in the journal name. In this way, we can identify all of the project management related journals in the business discipline. The list of the journals is shown in Table 1. All of these journals mention their acceptance and publication of the research in the field of project management. Then, to identify the articles containing the topic of the supply chain, we searched relevant keywords in each journal and screened the results following the guideline suggested by Liberati et al. (2009). In this process, we evaluated the topic of each study and excluded any research that was irrelevant to the current research. For example, the searching results with the keywords for abstract in PMJ gave an article of "Managing the Impact of Customer Support Disruptions on New Product Development Projects" by Ash and Smith-Daniels (2004). The later author comes from the department of SCM. However, that research paper exams preemption policies, which are irrelevant to SCM, therefore, as a result, was excluded in the current study.

In addition, for any articles studying the implementation and impact of SCM specifically in the construction industry, we excluded them in the current study. The purpose of this research is to provide a systematic view of implementing SCM in a project-based environment, and it calls for generalizability. We are more interested in the added value from identified key constructs to the process of SCM initiation and implementation rather than a specific industry. Fig. 2 shows the searching criteria and the results from each step. In the end, a total of 10 articles were obtained as the theoretical foundation of developing the systemigram in this paper. The number of articles selected from each journal is shown in Table 1. The summary of each article is shown in Table 2. Meanwhile, it should be noticed that the development of the current study relies beyond these theoretical foundation papers and involves an extensive review of broader literature coming from both SCM and project management fields. Each scene of the systemigram is discussed in the next section. The mainstay relies upon the study by Aloini et al. (2015). The selected theoretical foundation papers help categorize scenes 2 to 5 into different main themes, namely, coordination among project participants, IT integration, risk management, and supply chain complexity and resilience in project management. A number of research articles from the broader literature search contribute to the creation of additional nodes and the explanation of the inter-relationships among

Table 1
Referred journals and number of articles.

Journals	Number of articles selected
International Journal of Project Management (IJPM)	6
Project Management Journal (PMJ)	3
Built Environment Project and Asset Management (BEPAM)	0
Impact Assessment and Project Appraisal (IAPA)	0
International Journal of Managing Projects in Business (IJMPB)	1

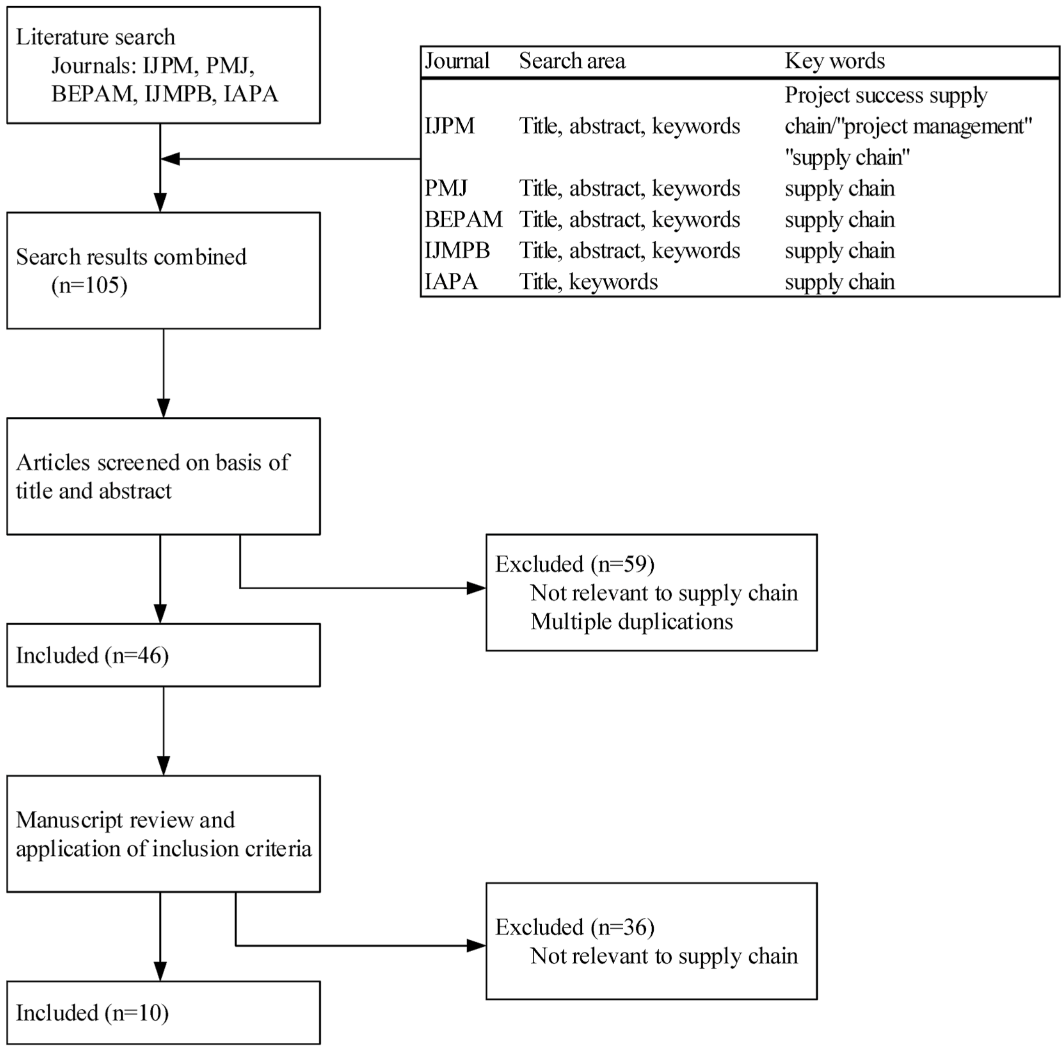

Fig. 2. Flow diagram of study selection.

these nodes. The authors' experiences and expertise in project management and supply chain was not readily apparent.

3.1. Scene 1: mainstay - implementation of SCM and contribution to the project management body of knowledge

The current study investigates the benefit of applying key components of SCM to the project management practice and the antecedents of the successful implementation. SCM, defined by Mentzer (2001), is "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole." To initiate SCM implementation, researchers find the necessary first step of supply chain orientation (SCO), which is a philosophy of implementing SCM in a firm that systemically recognizes various activities and processes through the supply chain (Mentzer, 2001; Min and Mentzer, 2004). It falls to both structural and strategic perspectives (Esper et al., 2010). When looking at the SCM implementation in the project-based environment, this study defines initial strategic orientation, which aligns to SCO, as the first step to start. Two key components are strategic planning among supply chain participants and commitment of top management in the initial strategic orientation. Strategic planning refers to the ability to make strategic decisions by introducing SCM and reaching to other participants in the supply chain to maximize the added value (Aloini et al., 2015). The commitment of top-management represents a series of key elements to support the successful execution of a project, including identifying the critical strategic areas, reviewing plans, resolving internal conflicts and following up the results from the implementation (Aloini et al., 2015). Together, they create commitment from all participants on the supply chain, which makes it possible for all of the stakeholders of the project to develop the congruency of objectives. There are four types of motivations that create congruency of goals and organizational alliances (Boddy and Macbeth, 2000; Faulkner, 1995):

- Resource dependency
- Spreading risk
- Speed to market
- Low costs

Long-term focus is another vital orientation for supply chain participants in terms of maximizing resource utilization and achieving desired outcomes, such as reduced cost, improved quality (Chen and Chen, 2007), and realization of affirmatory time frame. Trust lies between the long-term focus and sharing of information, risks, and benefits. It is crucial for developing and sustaining the relationship with other supply chain participants and is generally built over time (Sultan and Mooraj, 2001). Even though the nature of the project has a specific duration of time which is usually shorter than the time length of the

Table 2
Summary of the selected articles.

Article	Journal	Methodology	Industry	Topic/Purpose	Findings
Aloini et al. (2015)	IJPM	Interpretive structural modelling (ISM), case study	Shipbuilding	Identify key antecedents of SCM in a project-based environment	Identifies 16 key antecedents and three macro-classes of prerequisites.
Boddy and Macbeth (2000)	IJPM	Survey	Manufacturing	Supply chain partnering	Project goals, resources, structures, and controls are critical for successful supply chain partnering.
Braglia and Frosolini (2012)	IJPM	Observation/ framework proposal	Shipbuilding	Project Management Information Systems (PMIS)	Presents a combined approach to improve Project Management Information Systems (PMIS) applicability by integrating supply chain event management (SCEM).
De Rezende et al. (2018)	PMJ	Bibliometric analysis	N/A	Project complexity	Project complexity can be defined by dimensions with structural, uncertainty, novelty, dynamics, pace, social-political, and regulative. Developing project capabilities through the project's supply chain is necessary.
Fernando et al. (2017)	IJMPB	Survey	Automobile manufacturing	Project risk management (PRM) and green supply chain management (GSCM)	PRM and GSCM positively associate with project management performance and project success.
Hameri and Heikkilä (2000)	IJPM	Four case studies	Paper industry, telecommunication industry, software development, R&D	Management of time-critical operations and their dynamic interrelations in project environments	Highlights the importance of managing projects schedule by focusing on time-use within individual tasks and smooth chain of task flowing. Suggests three propositions regarding time-use of critical resources, transparency, and removing uncertainty.
Huin (2003)	IJPM	Case study (involving surveys and interviews)	Engineering	Three-level enterprise resources management model	Highlights organizational, operational and supply chain related interdependencies in small and medium sized enterprises (SMEs) and proposes a three-level enterprise resources management model that enhances decentralized, emergent and concurrent controls.
Rolstadås et al. (2015)	PMJ	Literature review	Manufacturing	Project decision chain	Defines a framework for decision making in projects.
Thomé et al. (2016)	IJPM	Bibliometric analysis	N/A	Relationships of complexity, uncertainty, risk, and resilience in SCM and project management	Both SCM and project management fields use similar conceptual definitions and have researches on risk management. Research on resilience appears only in SCM but not in project management.
Whyte (2019)	PMJ	Case study	Government	Project delivery models	Identifies three generations of integrated solutions and characterizes three project delivery models.

relationship in the traditional SCM industries, such as manufacturing and retailing, the prior ties between project members have been proven to facilitate the trust development (Buvik and Rolfsen, 2015). Then the high degree of mutual trust and respect acts as an essential project success factor (Chan et al., 2001) that enables the sharing among project participants in the supply chain.

The mainstay, as shown in Fig. 3, starts from the node of SCM implementation in the project-based environment on the top-left corner and ends on the contribution to the project management areas on the lower-right corner. Looking at the whole process, the mainstay is read as the following:

SCM implementation in the project-based environment begins with initial strategic orientation to create a commitment of supply chain participants to achieve congruency of objectives to support a long-term focus, which builds trust among the participants, therefore, enables the sharing of risks, benefits and information, thus contributes to the four project management areas of communication, procurement, stakeholder, land risk.

3.2. Scene 2: coordination among project participants

Project management and SCM have direct similarities (Rolstadås et al., 2015). SCM requires strategic coordination, and value is added from each stage of the supply chain (Mentzer, 2001). Project management also has constructed processes that guide and manage the workflow between each project team member. Human resource is highly involved and centered in such process. A number of studies suggest that human collaboration in a project is not a natural behavior and has to be developed (Calamel et al., 2012; Hoegl et al., 2004; Ring and Van de Ven, 1994). Fig. 4 depicts the scene of coordination among project participants. When integrating SCM into project management practices, adequate coordination measurements are necessary antecedents for a successful SCM adoption (Aloini et al., 2015; Fawcett et al., 2008). Aloini et al. (2015) classified those rules and procedures as autonomous antecedents and emphasized the importance of supply chain performance measurements and multi-criteria based member selection procedure. On the one hand, the predetermined selection criteria are mutually accepted by all of the project team members and therefore enhance a proper relational behavior that leads to a long-term focus across organizations. On the other hand, project managers should have adequate capability to effectively create trust and resolve distrust in order to sustain a long-term relationship among participants and build firm's reputation (Lewicki and Wiethoff, 2006). In the R&D and innovation related projects, the coordination between manufacturing and marketing as well as between manufacturing and supply chain are positively correlated with innovation success. The multi-criteria and supply chain performance based selection procedure will ensure a high level of supply chain intelligence quality, which positively moderates the relationship between the coordination and innovation performance (Mostaghel et al., 2019).

Looking from the supply chain perspective in a project, numerous small and medium sized enterprises provide services and contribute to the project especially in the manufacturing industry such as shipbuilding and electronics engineering. Interactive conflict among these supply chain participants often exists that threatens the effective resource utilization and ultimately the project success. To deal with this potential confliction, project manager may consider a three-level resource management model proposed by Huin (2004) while selecting the project

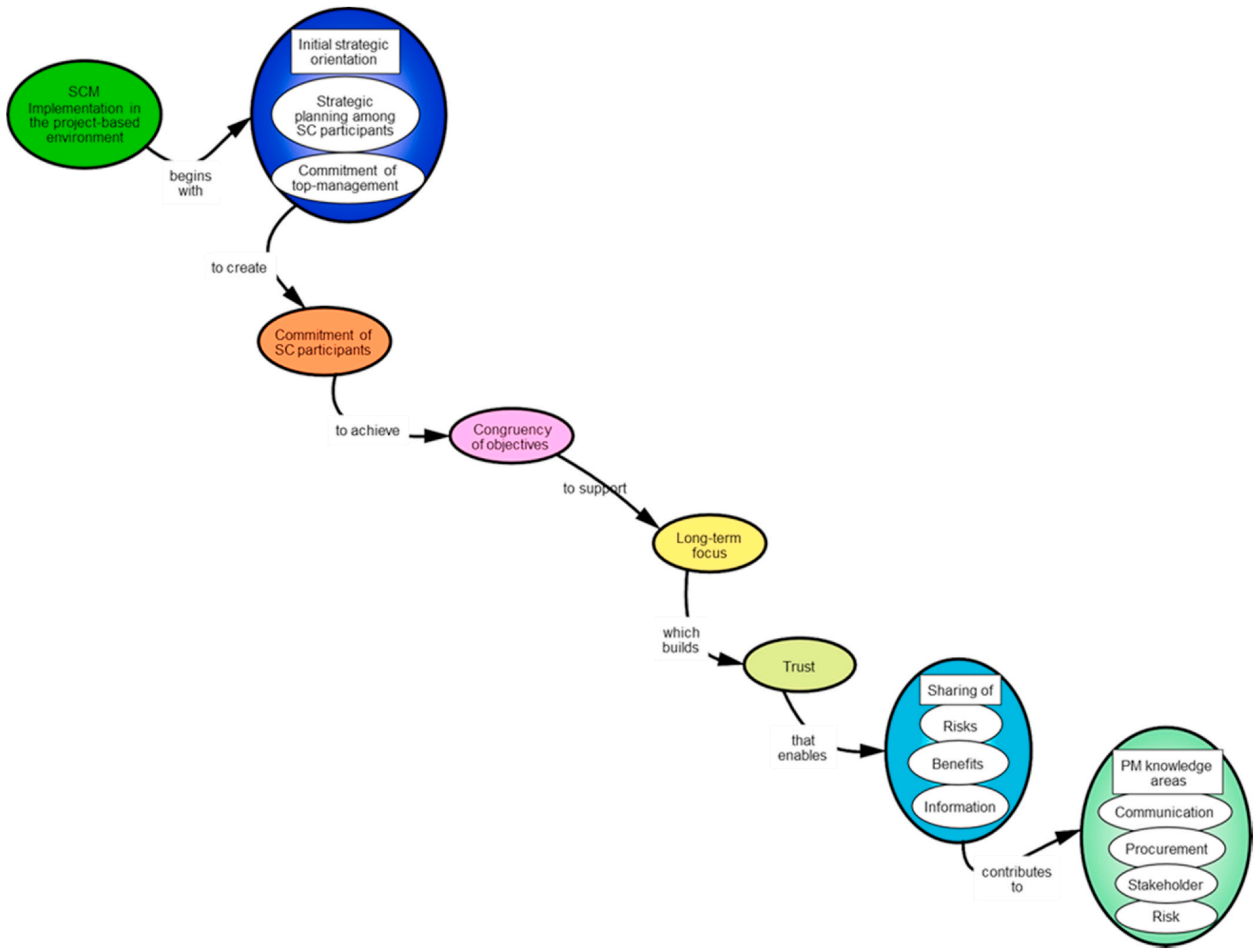

Fig. 3. Implementation of SCM and contribution to the project management body of knowledge.

team members based on a series of criteria. The model clarifies the relational behavior into three hierarchical roles, where the coordination level, as the top level, provides information and strategic direction to the decision level. The decision level is considered as the second level that consists of several planning agents. Operational plans are made in the second level. The lower level, defined by Huin (2004) as the operational level, receives the plans came from the decision level and execute those plans. This coordination-planning-execution process also aligns with the framework for decision-making in projects proposed by Rolstadås et al. (2015). The benefit of this relational behavior with a three-level architecture is the separation of roles for each project participant that enhances decentralized, emergent, and concurrent controls.

3.3. Scene 3: IT integration

In addition to scene 2, congruency of objectives also calls for IT integration, as shown in Fig. 5, that promotes organizational collaboration and eliminates information asymmetry (Aloini et al., 2015). The application of emerging technologies, for example, blockchain (Kshetri, 2018; Min, 2019) and big data analytics (Waller and Fawcett, 2013), in SCM is a contemporary research topic. Similarly, the studies regarding project management related information systems and advanced technologies have drawn researchers' attention as projects become more complex (De Rezende et al., 2018). Those emerging technologies create pervasive digital information and facilitate digital channel that transfers information in real-time, which makes possible of integrated solutions. Whyte (2019) called it as the first generation of digitally enabled project delivery model. As the digital information becomes increasingly pervasive, integrated solutions transit to digitally-supported integrated solutions, and ultimately transit to digitally integrated solutions. Three distinct characteristics of digitally integrated solutions are identified as digital twin in delivering the project, supplier visibility within organizational interactions, and the user-led relationship between operator and end-user (Whyte, 2019). Digital twin means that the deliverable products or services are digitally enriched, which offers more complex and customized solutions beyond a traditional bundle of services and goods (Johansson et al., 2003). Supplier visibility stands for a high level of transparency. Lastly, user-led relationship indicates the influence of the end-user to the IT system and the final solutions rather than the focus of the traditional owner-operator relationship. Thus, the third generation of digitally integrated solutions creates incrementing value through the collaboration between provider and customer (Brax and Jonsson, 2009). Because of the IT advancement in last two decades, various advanced systems have become available and are potential choices for project managers. For example, a specially designed web supporting system based on the Intelligent Wireless Web could enable the capability of real-time supply chain coordination, provide a lower cost integration opportunity and service discovery, and satisfy long-term project goals (Soroor et al., 2009). In the construction industry, an Internet-enabled coordination system could offer functions including information exchange, online negotiation, dialogue for agents' goals, traffic volume monitor and more (Xue et al., 2005). Such technology provides an

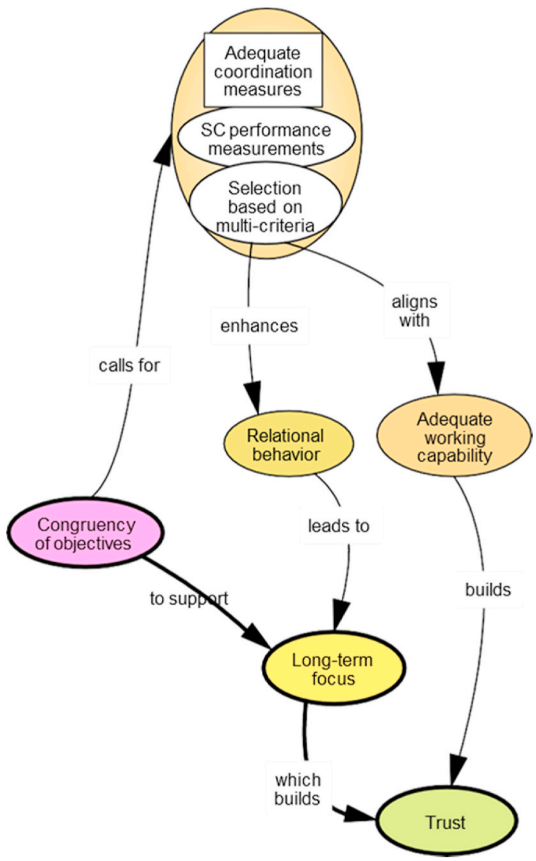

Fig. 4. Coordination among project participants.

efficient coordination platform that allows improving performance and accelerating innovations (Xue et al., 2007).

However, digital information becoming available does not necessarily mean that information is appropriately used and integrated into deliverables. In the Information System (IS) area, studying the technology adoption and usage remains a contemporary topic (Im et al., 2011; Moores, 2012; Venkatesh et al., 2012). In the logistics and SCM context, similar studies also exist. For example, Chong et al. (2015) studied potential RFID adoption in the healthcare supply chain. Lai et al. (2018) investigated the determinants of big data analytics adoption in logistics and SCM through an empirical study and found direct relationships from perceived benefits of technology and top management support in the organization to the intention of big data analytics adoption. One of the articles that met the selection criteria for the literature review in the current study is “How Digital Information Transforms Project Delivery Models” from the *Project Management Journal*. In that study, Whyte (2019) proposed three project delivery models that are digitally enabled. The first is the owner-operator (where the owner uses the digital information and supplier updates the information). The second is the pop-up client (who acts as a delivery partner and provides digitally integrated information to both owner and supplier). The last is the integrated pop-up client (who is also responsible for system integration). As project becomes more complex and involves SCM, it is critical for project managers to adopt the best approach that meets the managing and coordinating requirements. For example, in the shipbuilding industry, it is beneficial to integrate a project management information system (PMIS) with the supply chain event management (SCEM) paradigm, where PMIS manages time-phased requirements and SCEM handles supply chain related operational processes (Braglia and Frosolini, 2014).

Therefore, this research argues that only with the proper adoption and actual usage of the best-suited technology that manages pervasive information, companies can benefit from digitally integrated solutions and transformation of traditional project delivery models. In academia, the study of technology adoption and usage in project management appears to be an attractive future research area.

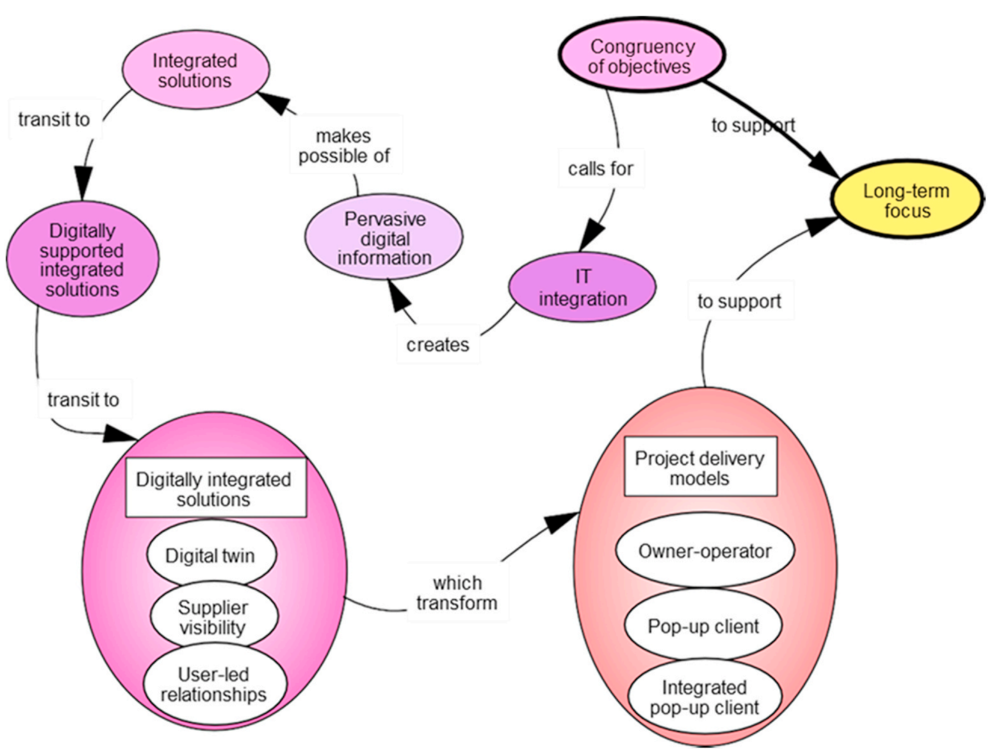

Fig. 5. IT integration.

3.4. Scene 4: risk management

Once the trust is built among project team members through the supply chain, the ultimate antecedents of the potential successful SCM implementation would be the sharing of information, benefits, and risks across organizations. Aloini et al. (2015) classified those as the dependent variables in their model. Due to the uniqueness of each project, risk and uncertainty are inherent factors to a project and can reduce the predictability of project success. The risk and uncertainty in business operations arise at three levels, which are environmental level, industry level, and firm-specific level that includes network and organizational uncertainty (Gaonkar and Viswanadham, 2007; Miller, 1992). The sharing of risks naturally calls for proper activities and tools of risk management, which are essential in the project-based industries, such as construction industry (Akintoye and MacLeod, 1997; Carbonara et al., 2014; Olsen and Osmundsen, 2005), aircraft industry (Figueiredo et al., 2007), and ship-building industry (Aloini et al., 2015). The general steps of assessing and managing supply chain risks are also transferable to project-based environment. Tummala and Schoenherr, (2011) classified those steps into three phases, where the first phase involves risk identification and measurement. The second phase involves risk evaluation and proposing risk mitigation and contingency plans. In the third phase, project leaders will monitor the risk control progress and examine project performance. Proper risk management strategies and programs will strengthen the company's ability to face various risk sources, which in turn interact with risk management and result in better risk mitigation (Thomé et al., 2016). This logic is also consistent with Manuj and Mentzer's (2008) proposed model for managing and mitigating supply chain risks. However, it is notable that each risk managing strategy could be put into effect in conjunction with other strategies and different combinations of strategies can produce different results. For example, creating low transparency about a supply risk by keeping other project participants out of the loop may reduce the risk of project postponment or delay. Another strategy for creating high transparency of risk exposure by highlighting the risks in decision bodies could improve planning and therefore reduce project delay risk (Willumsen et al., 2019). In the last two decades, the area of risk management and its impact on project performance have generated fruitful research (Fernando et al., 2018; Kutsch and Hall, 2010; Ward and Chapman, 2003). The PMBOK also has a separate chapter of risk management.

This section of the research does not intend to review any detailed findings or specific tools to mitigate project risks but aims to clarify the relationships between those variables that have been identified to be critical for a successful SCM and how project managers can use these knowledge to guide practice. Drown upon existing literature, Fig. 6 visually demonstrates this feedback loop. In the next section, we continue expending the loop to investigate the relationship between risk management and project complexity involving supply chain.

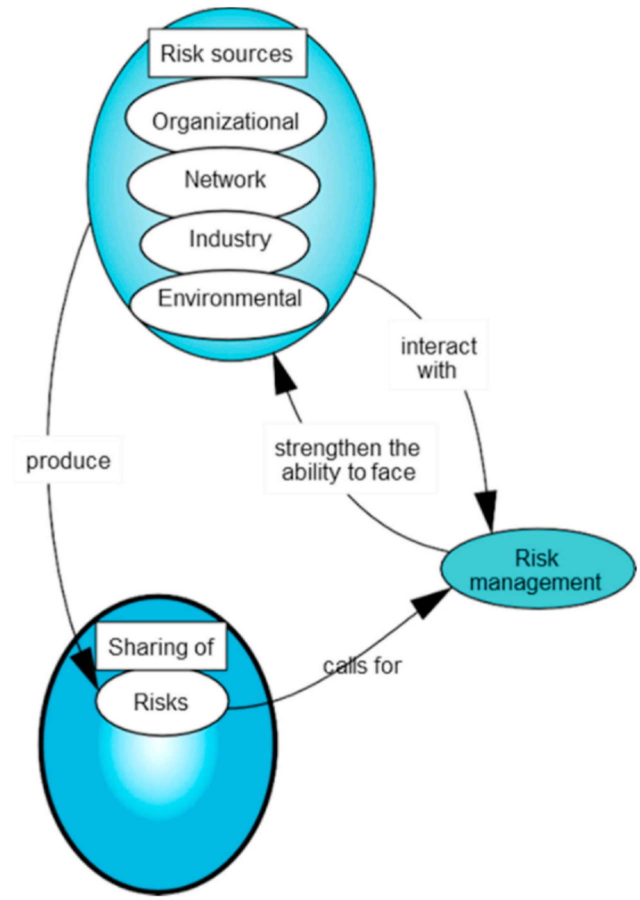

Fig. 6. Risk management.

3.5. Scene 5: supply chain complexity and resilience in project management

The research on project complexity is an emerging topic. When supply chain is relevant to a project, the research focus expends from a single organization or team to the entire supply chain of the project to seek increased project adaptability and managing capability (De Rezende et al., 2018). In addition to scene 4, risk management also drives to build supply chain resilience (Thomé et al., 2016), which has four main categories of risk managing and mitigating strategies, including flexibility, redundancy, collaboration, and agility (Tukamuhabwa et al., 2015). The study of supply chain resilience is an emerging topic in logistics and SCM beginning in 2000 aiming to gauge supply chain professional's awareness of supply chain vulnerability and mitigate the risk of supply chain disruption (Christopher and Peck, 2004; Cranfield University, 2003; Ponomarov and Holcomb, 2009; Sheffi, 2005). One of the major advantages of supply chain resilience is it supplements the risk management by dealing with unpredictable supply chain disruption, thus, creating a competitive advantage for the firm (Pettit et al., 2010). In the field of project management where supply chain is a relevant component, the influencing factors to supplier resilience include supplier geographic location, variability in cost of supplies, variability in quality parameters, technical capability of suppliers, variability in lead time, and supplier flexibility (Shishodia et al., 2019). Therefore, the strategies proposed by Tukamuhabwa et al. (2015) are transferable to the project-based environment and are likely to be applicable in managing and mitigating the potential risks associated with these influencing factors.

Aligning with extent literature, supply chain complexity originates from the external and internal environment and supply-demand interface, and those origins cross-reference with different types of complexity as shown in Fig. 7. In the field of project management, time is a critical criterion to measure performance. Coordination of interfaces among each supply chain participant and between consecutive project tasks contributes to project complexity. The ignorance of such interfaces and lack of time-based management often make a project fail (Hameri and Heikkilä, 2002). Serdarasan (2013) classifies complexity into three types of drivers, which are static, dynamic, and decision-making. Static complexity refers to the complex supply chain structure, a higher number of product/production and supplier/customer that cause variety and increased interactions, and new technologies. Dynamic complexity describes uncertainty and randomness over time in the supply chain, for example, lack of process control over time, prediction, uncertainties coming from human resources and others. The last driver classification is decision-making, which relates to the organizational structure, IT systems, and external environment change. The uncertainty comes from the various drivers of supply chain complexity and leads back to the risk sources (Simangunsong et al., 2012; Thomé et al., 2016). To overcome

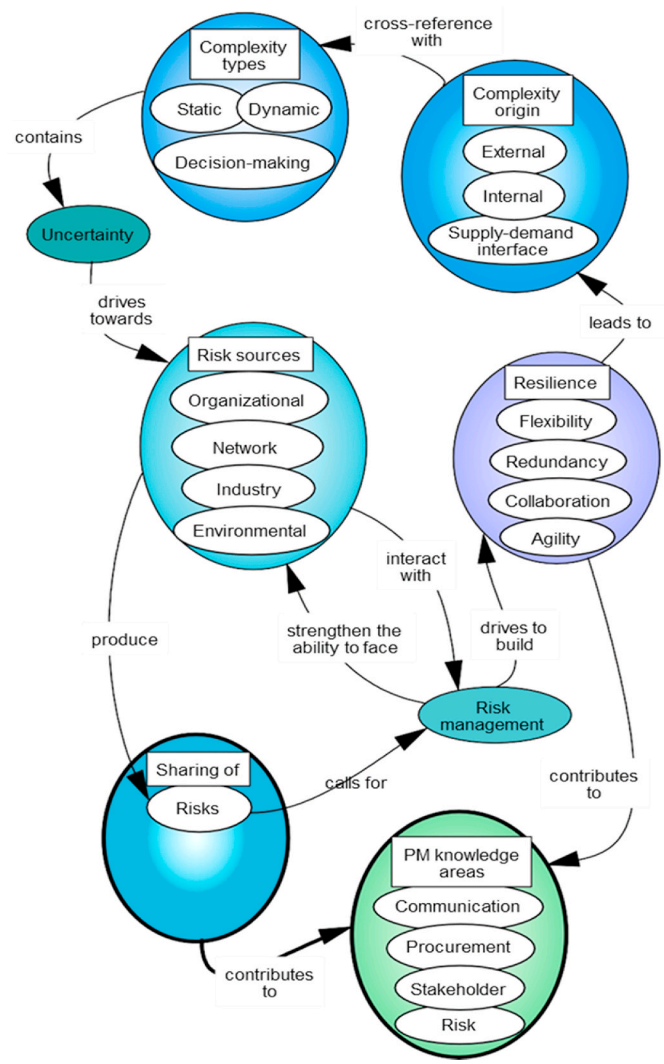

Fig. 7. Supply chain complexity and resilience in project management.

those risks that jeopardize the project performance, project managers should focus on managing the time-use of critical resources, increasing transparency of the interfaces from task to task, and removing uncertainty from each supply chain participant and individual project tasks (Hameri and Heikkilä, 2002).

4. Discussion

4.1. Theoretical contribution

In the project-based environment where various suppliers and different parties are involved and working collaboratively, project managers could benefit from SCM concepts and techniques to improve project performance. The current research qualitatively synthesizes the relevant literature and proposes a conceptual framework of integrating SCM to project management when it is applicable. In this study, the systematic literature review and results visualization using systemigram conclude the critical antecedents for a successful implementation of SCM in the project-based environment and the inter-relationships among each element. The mainstay depicts the complete process of initiating SCM implementation and how this practice contributes to project management knowledges. Besides the mainstay, the current study categorizes these critical elements into four main areas: IT integration, organizational coordination, risk management, and supply chain resilience and complexity. Fig. 8 shows the holistic view of the systemigram. To achieve the theoretical integration of SCM and project management, this study explored beyond just a single domain of construction industry as is in many social science studies (Brusoni and Prencipe, 2006; Edum-Fotwe and McCaffer, 2000). The generalizability of the findings is gained from a thorough examination of relevant literature within the business discipline. Using the systemigram, we visually present a systematic view of this theoretical integration.

4.2. Insight for practitioners

The congruency of objectives appears to be a critical part linking organizational strategy to successful SCM implementation based on the visual presentation of the systemigram, where these relevant relationships are clearer than from text alone. The importance of congruency of objectives presents in three distinct places as the outward arrows shown in Fig. 8. First, the congruency of objectives calls for IT integration, which determines the way the information flows within organizations and transforms project delivery models. At the beginning of every project, it is important to identify customer's needs and specify relevant requirements. The project success could be measured by the level of satisfaction of such needs, where a well-developed information system largely contributes to success. In the process of developing an information system used by the stakeholders, both the project managers and the system users in each stage of the supply chain should involve in the development cycle. These partnering activities help prevent a lack of user support, thus improve project performance (Jiang et al., 2002). The resulting information system with interface congruency can have a profound impact on both business settings and business-customer relationship that best suit the needs of practitioners (Rho et al., 1994). In the current study, congruency of objectives links the commitment of supply chain participants and IT integration. This also aligns with Reich and Benbasat's (1996) results investigating the measurements of the linkages between business and IT integration objectives, where the findings indicate that the mutual understanding of current objectives and congruency visions of IT integration properly measure the linkage in short- and long-term, respectively.

Second, congruency of objectives calls for adequate coordination measures, including the criteria-based selection of supply chain participants and their performance measurements. This contract-based governing mechanism will promote inter-organizational cooperation (Huang et al., 2014), thus positively contribute to the outcome of inter-organizational projects (Lu et al., 2019). Adequate coordination measures also ensures a high level of supply chain intelligence quality, which is positively associated with project success.

Third, congruency of objectives supports long-term focus. Apart from the insights for project managers, the current study applies to all of the supply chain participants because they are stakeholders of the project. By governing temporary projects, an organization derives value from the execution of its projects. Furthermore, estimating and maintaining long-term relationships among shareholders beyond sole project execution will maximize such value (Riis et al., 2019).

4.3. Contribution to project management knowledge

The interpretation and knowledge codification of the systemigram presented in the current study complement the existing project management body of knowledge (PMBOK) areas. In PMBOK (2017), the term SCM appears only once in describing the Project Procurement Management knowledge area, which suggests the need for increasing the emphasis on SCM among project teams. For leaders who are managing a complex project, a high degree of situational information visibility, such as resource availability, scheduling options, and associated costs, influences the project managers' understanding of interrelated activities, increases their rational resource sharing and requesting behaviors, and ultimately influences immediate and future project performance (Bendoly and Swink, 2007). When the supply chain becomes an integral

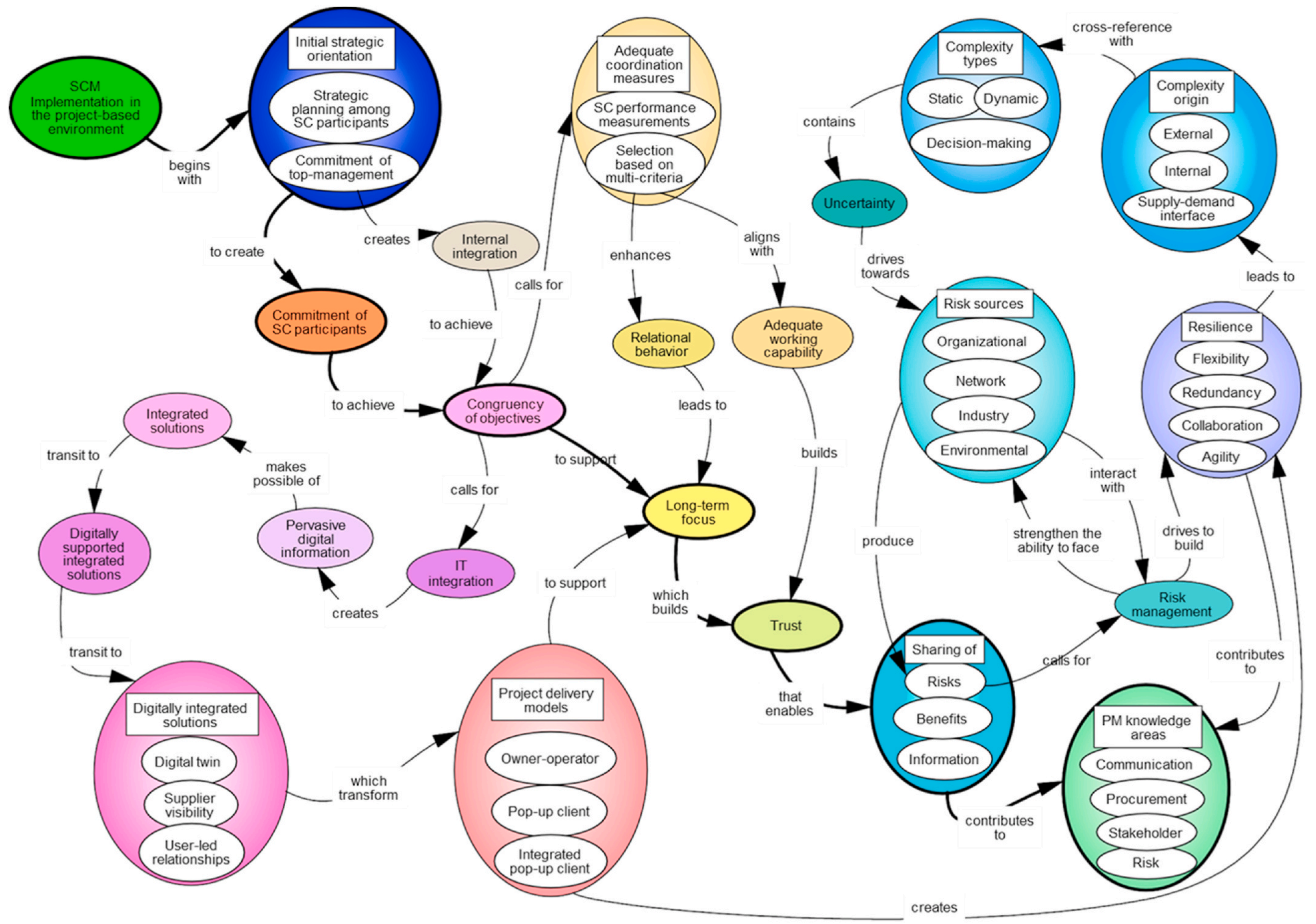

Fig. 8. Holistic view of systemigram.

part of the project-based environment, proper managing and collaborating strategies become even more critical for project success. However, the gap exists between the emphasis of SCM where is needed and the understanding and knowledge on how to implement SCM in a project. This study identified this gap and started to fill the gap by illustrating a theoretical integration of SCM and project management and discussing its practical implications for the first time. Built upon the extent literature and with the help of process visualization using the developed systemigram, the current study provides a high-level conceptual framework guiding SCM implementation in a project management context. This study also supplies a resourceful list of references that project managers can use for in-depth understanding of such integration and as a guide for designing customized strategies that best fit specific industry and their unique needs.

5. Conclusion

The current study contributes to the management of projects that involve supply chain participants in several ways. First, this research identified and categorized the key antecedents of successfully initiating SCM implementation in projects into IT integration, organizational coordination, risk management, and supply chain resilience and complexity in project management. Second, the inter-relationships between these antecedents were explored. Third, this research used a systemigram to present visually the conceptual integration of SCM and project management derived from a systematic literature review in the business discipline. In the process of developing such systemigram, this research explicitly introduced the rules of designing a systemigram and illustrated how value is gained using it. Utilizing systemigram overcomes the limitation of the linear text reading and helps one to understand a complex system.

Notwithstanding the contributions of the current study, when applying the proposed conceptual framework in guiding SCM implementation, project managers need to consider the following limitations. First, this conceptual framework is intended to explain the key antecedents of integrating SCM within projects and their inter-relationships at a high level. Practitioners should tailor the framework to fit better a specific application in their business practices. In addition, there exists uniqueness in every industry, where the emphasis on the importance of the identified factors may differ. The interpretation of this theoretical integration is context-dependent. For example, spreading and mitigating risk calls more managers' attention in construction companies (Segerstedt and Olofsson, 2010) than in many other industries. The time constraint in the volatile construction market also alters a series of strategic decisions regarding product development, process innovation, and capacity planning (Rho et al., 1994). Third, the current study reviews only relevant literature from project management journals. It is possible that some papers embody project thinking and are published in other literature streams such as in supply chain management journals.

At the same time, those limitations reveal potential research directions. While this study identifies the key elements and explores their relationships as most salient for SCM integration in project management, further exploration of each category can allow addressing supply chain dynamics (Swaminathan et al., 1998; Towill, 1991) in a manner relevant to different specific contexts. For example, it is worth exploring the impact of supply risks on project success in different contexts and industries. Future research could also examine this theoretical integration in a case study context.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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