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Creating and Sharing Interorganizational Knowledge Through a Supply Chain 4.0 Project: A Case Study

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ABSTRACT

Digitalization in the supply chain involves important transformations in the relationships between supply chain partners. Studies investigating these transformations underline the need to create and share new knowledge processes in order to achieve successful digital projects that improve integration and collaboration in the supply chain. This article proposes to make a parallel between the stages of the SECI model concerning knowledge conversion and the different phases of a Supply Chain 4.0 project. By using a longitudinal case study, the authors fill the gap on the dynamics of knowledge transformation in supply chain digital projects. Based on a supplier portal project, the case study presented helps to understand how to ensure that the different partners will get fully involved in the digital project. It provides five managerial recommendations for companies that wish to commit to supplier development and knowledge sharing through digital projects.

KEYWORDS

Case Study, Digitalization, Information Technology, Interorganizational Knowledge Sharing, Knowledge Management, SECI Model, Supplier Portal Project, Supply Chain 4.0

INTRODUCTION

Digital technologies from industry 4.0, such as blockchain (Buthelezi *et al.*, 2021), but also cloud platforms, the Internet of Things (IoT) or artificial intelligence (AI), are disrupting traditional supply chain management and are creating new opportunities and benefits for digital-enabled companies. Often referred as supply chain 4.0, this current revolution reinforces the need for more connectivity, inter-operability, integration and collaboration (Zekhnini *et al.*, 2020). Supply chain 4.0 describes recent developments in logistics management based on networking, digitalization and cloud computing.

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The most advanced communication and information technologies facilitate the implementation of intelligent and digital networks that connect people, facilities and products so that they communicate directly with each other for a better agility, flexibility and information transparency (Bi *et al.*, 2013; Frederico *et al.*, 2019; Ada *et al.*, 2021; Tsai and Lasminar, 2021).

In this context, digitalization induces a rapid growth of available data in the supply chain and a subsequently development of information sharing between companies (de Corbière *et al.*, 2019). Yet the way these data and information are used does not always ensure improvement of supply chain collaboration and integration¹, especially with external stakeholders (Schneiderjans *et al.*, 2020). The continuous development for several decades of global supply chains leads companies to use external stakeholders, in particular their first-tier and second-tier suppliers, located thousands of miles away, which necessarily impacts the nature of the information systems. The digital transformation of global supply chains requires companies to reengineer their processes, to adapt human skills and to develop new ways of collaborating with their partners, including a strong user involvement in IT innovation (Chen *et al.*, 2020). New knowledge linked with this transformation needs to be created and shared within the supply chain, and the consequences of supply chain 4.0 technologies for knowledge management are largely discussed in academic literature (Durst and Evangelista, 2018; Cheah and Tan, 2021; de Bem Machado *et al.*, 2022).

Considering the whole supply chain, each partner develops a different degree of technological maturity, so the assimilation of a new technology may encounter barriers in some low-tech companies where knowledge management practices are under-used (Law *et al.*, 2021). Therefore, when adopting a new technology, supply chain focal firms should create and share interorganizational knowledge in order to help their partners (suppliers or retailers) achieve alignment and adaptation, which impacts operational performance (Marra *et al.*, 2016), including sustainable goals (Uniyal *et al.*, 2021). Regarding the relationships between a focal customer and its suppliers, it is necessary to actively support suppliers in the process of appropriation of new knowledge and use of the information (Handfield *et al.*, 2019), by developing social interactions to facilitate the knowledge appropriation and IT adoption (Mengesha *et al.*, 2021). This top-down approach can be enriched by a bottom-up approach allowing suppliers to share knowledge or to make proposals for improvements (Rebolledo and Nollet, 2011).

In the context of supply chain digitalization, supplier portals occupy a central position. The objective of a supplier portal is to propose to the supplier of a buying company a simple and instantaneous access to all information related to business transactions via a cloud service, whether it concerns past transactions or future projects. The supplier portal provides a centralized point of contact that offers many benefits to both the buying company and the supplier. On the buying company's side, data is immediately available in the right format and can be transmitted to information systems such as enterprise resource planning (ERP) without delay. In addition, the data is entered directly by the supplier, which saves time and reduces errors, while ensuring secure access to the portal. On the supplier's side, a structured nomenclature of product families and attributes is available, facilitating participation in tenders. In addition, the availability of statistics on business transactions helps improve performance and anticipate customer needs. In brief, the supplier portal facilitates the circulation of information and automates workflows to optimize supply chain management (Boyson *et al.*, 2003).

This article investigates the dynamics of knowledge creation and sharing in a supply chain digital project concerning various stakeholders around the implementation of a supplier portal. For this purpose, we chose to overlay the SECI –for “socialization”, “externalization”, “combination” and “integration” – model of knowledge transformation (Nonaka, 1994), with the different phases of the project. This analysis helps to better understand how this shared knowledge plays a role in facilitating integration and collaboration in the supply chain. Based on a longitudinal case analysis covering four years which provides the necessary temporality to study the knowledge dynamics along the project. In the light of the lessons learned from knowledge transformation throughout the project, we formulate five recommendations for managers who wish to undertake a new digital project in a

supply chain 4.0. The number of failures in supply chain digitalization projects should encourage supply chain managers to take them into consideration².

THEORETICAL FOUNDATION

In parallel to the study of intraorganizational knowledge sharing (Hsu and Wang, 2008), interorganizational knowledge management can be conceptualized as comprising three main processes: (1) acquiring new knowledge from partners; (2) sharing knowledge with partners; and (3) creating new knowledge in business collaboration (Easterby-Smith *et al.*, 2008; Lancini, 2015; Sudhindra *et al.*, 2020; Garousi Mokhtarzadeh *et al.*, 2021). Interorganizational knowledge sharing across organizational boundaries involves micro-processes and routines within and outside a company directed to reaching a collaborative macro-strategy (Loebbecke *et al.*, 2016). Interorganizational learning implies interaction between humans and technologies (Plangger *et al.*, 2020), but is also impacted by trust relationships between the partners. It is indeed essential that everyone believes that the other parties are acting in the mutual interest of the project; this means the existence of interorganizational trust in the collaborative behavior of supply chain partners (Cao and Zhang, 2013).

Explicit and Tacit Knowledge

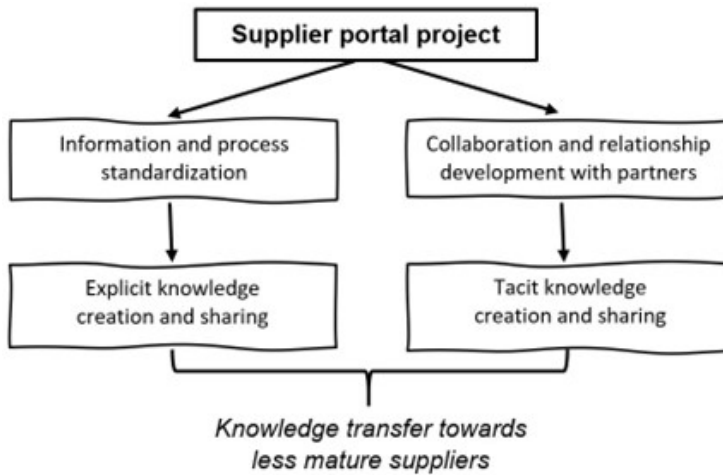
Tacit and explicit knowledge are commonly differentiated in the context of supply chain and technology knowledge issues (Evrard Samuel *et al.*, 2011; Schoenherr *et al.*, 2014; Suhindra *et al.*, 2020; Qiao *et al.*, 2021). While Polanyi (1966/2009) first defined explicit and tacit knowledge in its human dimension, Nonaka (1994) and Nonaka and Takeuchi (1995) expanded this concept to organizational and interorganizational knowledge. Explicit knowledge refers to codified and documented knowledge embodied in written documents, procedures and databases of the organization. Information and communication systems such as ERP, the most common type of standardized information systems architectures (Bidan *et al.*, 2012), or collaborative platforms are the main drivers of explicit knowledge sharing in the supply chain.

On the other side, tacit knowledge is personal and specific to an organizational context. It refers to technical know-how or skills, and to cognitive viewpoints, beliefs, or paradigms. It is based on experience, mental processes or memory which have not been formalized. Tacit knowledge is exchanged through communication, observation and social interactions. In brief, tacit knowledge cannot always be articulated in a codified form; it is implicit and draws on the experience of the person who possesses it. Being non-tangible in nature, tacit knowledge can be difficult, if not impossible, to articulate in a form that can be used by others. If we extend the analysis to an organizational level, tacit knowledge consists of solving practical problems that have not been foreseen or formalized by the organization through skills, know-how, abilities and intuitions, as underlined in the meta-analysis of Thomas and Gupta (2022).

Supplier Portal Project

Supply chain collaborative processes are grounded in exchanges of information, but also in interpersonal and interorganizational relationships (Ralston *et al.*, 2017; Verhoeven and Nitsche, 2018). We focus here on the implementation of a supplier portal that deals with the procurement process. Supplier portals usually use a private cloud-based platform that enables standardized information sharing and transactions between one or several focal firms and their suppliers. This kind of project allows supply chain partners to transform shared tacit knowledge into a more explicit form (see Figure 1). Such projects play a role in creating interorganizational standard processes in the supply chain by codifying vocabulary, by exchanging formatted documents and by defining business rules or best practices. They can also amend communication and relationships between individuals (Barãoa *et al.*, 2017), and help to develop a new shared meaning between supply chain partners, which implies new tacit interorganizational knowledge creation and sharing (Malhotra *et al.*, 2007).

Figure 1.
Role of explicit and tacit knowledge in supplier portal projects



Incorporating knowledge management activities into day-to-day business processes should facilitate learning and creation of organizational and interorganizational knowledge, so these portals are particularly relevant to integrating both business processes and knowledge processes (Clarke III and Flaherty, 2003; Baglieri and Secchi, 2007; Teixeira and Borsato, 2019). More broadly, it is understood that the digitalization of a supply chain requires a high level of integration of the various partners' capabilities (Queiroz *et al.*, 2021). However, the partners' use of these portals may not be as high as expected because suppliers have to work with many different tools and the focal firm may need to provide ongoing encouragement or pressure to facilitate assimilation (Garcia and Grabot, 2015; de Mattos and Laurindo, 2017). One of the challenges of such digital procurement projects consists in taking along suppliers and develop with them new interactions and knowledge (Handfield *et al.*, 2019; Cox, 2022); the SECI model is well adapted to answer this issue.

SECI Model of Knowledge Transformation

Nonaka (1994) and Nonaka and Takeuchi (1995) SECI's model uses the distinction between explicit and tacit knowledge to describe the creation of organizational knowledge and interorganizational knowledge. The spiraling process of knowledge creation and sharing proceeds in four stages called SECI, which stands for socialization, externalization, combination and internalization. It follows a path from the individual level, to group, organization and interorganizational exchange systems, and the loop ends with a return to the individual:

- *Socialization* is the first step in knowledge conversion and consists of exchanging tacit knowledge and experience between individuals during formal and informal interactions.
- *Externalization* is the second step of the cycle and occurs when individual tacit knowledge is converted in explicit knowledge shared by a group. The need to formalize and codify the tacit exchanges generates information exchange through documents, contracts and databases.
- A third step, *combination*, then creates the organizational and interorganizational knowledge by communicating the explicit knowledge generated in the former phase at, for example, the organizational level or at the supply chain network level. In this stage common information tools are developed and used.

- The last step consists of the appropriation (*internalization*) of the organizational or interorganizational knowledge and tools by individuals through a process of learning by doing. Thus, individuals create new routines and become more competent.

Nonaka and Konno (1998) enhance the seminal model by adding that a supportive physical, mental and virtual environment, which they call “Ba”, enables interactions and is necessary for the successful process evolution; the “Ba” should be seen as a common place of emergent relationships between individuals and between individuals and their environment, which allows them to share time and space, either physical (the office or dispersed workplaces), or mental (experiences, ideas), or a combination of both. Lopez-Nicolas and Soto-Acosta (2010) show that IT adoption and use affects more externalization and combination steps than socialization and internalization steps due to the influence of tacit knowledge. Tyagi *et al.* (2015) investigate how lean tools facilitate knowledge creation through the SECI model in product development projects including internal and external stakeholders. Shrivastava *et al.* (2021) overlay the hiding knowledge process on the SECI model while using a multilevel analysis across individuals, groups and organizations. Finally, Borodako *et al.* (2021) underline the dynamics of knowledge management process and the moderating role of ICT in the SECI model.

In a supply chain context, Wu (2008) applies the four stages of the SECI model to highlight knowledge creation and sharing between supply chain partners and characterizes the “Ba” collaborative context according to the different process stages. The investigation conducted by Evrard-Samuel *et al.* (2011) underlines that the combination step is little mentioned by supply chain companies since they encounter difficulties to implement this step. Kó *et al.* (2019) identify the SECI stages at stake and the technological tools used for knowledge management depending on the different supply chain key processes. Indeed, virtual tools facilitate internalization of explicit knowledge and helps knowledge management with suppliers through socialization and combination steps (Canónico *et al.*, 2020).

Research Gap

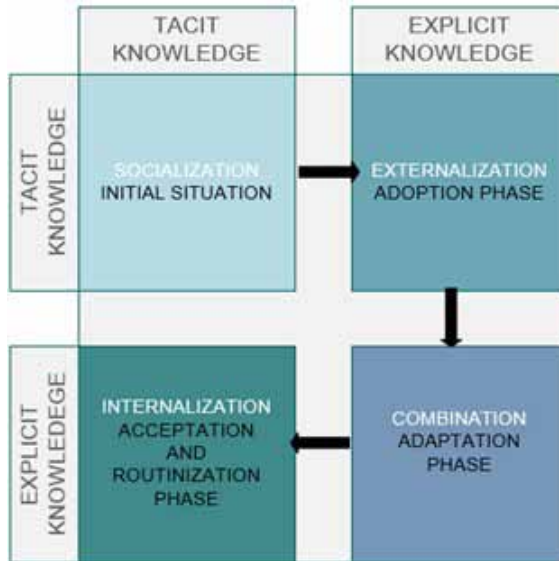
Therefore, the SECI model is well adapted to study interorganizational knowledge creation and sharing in supply chains, but there are few studies of such processes that use SECI model considering different stakeholders –either internal or external– of the same supply chain. This literature review reveals a research gap about how knowledge transformation supports supply chain digitalization projects concerning various stakeholders (Durst and Evangelista, 2018; Schniederjans *et al.*, 2020). Besides, all these authors underline that the interest of the SECI model is based on its dynamic evolution. A long temporality, from several months to several years, should be required to study this knowledge dynamics whereas most of the studies are based on quantitative or qualitative single surveys that do not allow for such a temporality. Using a longitudinal approach based on a case study should help to fill this gap (Lopez-Nicolas and Soto-Acosta, 2010; Loebbecke *et al.*, 2016).

To highlight the model’s dynamic evolution and to take into account the temporality of the digital project, we divide the project into four phases with a simplification of the phases that were proposed for information technology implementation by Cooper and Zmud (1990): the initial phase before adoption, the adoption phase, the adaptation phase and the acceptance and routinization phase that takes place after the portal implementation. Figure 2 draws a parallel between the four SECI stages and these four project phases. We apply this model to analyze a supplier portal project, called Electra case (a pseudonym). This project aimed to digitalize procurement in the context of customer-supplier relationships, which is in line with the central role given to the supply portal in the formalization of an integrative framework for supplier relationship management (Park *et al.*, 2010).

RESEARCH METHODOLOGY

In order to address the above-mentioned project temporality, a longitudinal case study was conducted. Indeed, such a method makes it possible to examine process changes throughout the duration of a

Figure 2.
 Combining project phases with the SECI model



project and after its implementation (several years), rather than obtaining a snapshot at a given moment (Street and Ward, 2012), which would not reflect the expected dynamics. Indeed, Eisenhardt (1989, p. 534) points out the utility of a case study for “*understanding the dynamics present within single settings.*” Moreover, the case study is a particularly interesting research methodology in the field of information systems (Benbasat *et al.*, 1987; Irani *et al.*, 1999; Dubé and Paré, 2003), and logistics management (Ketokivi and Choi, 2014; Cunha Dolci *et al.*, 2015), where technology is constantly evolving and where the complexity of the context is notable. Thus, the case study approach is suitable for our research because, on the one hand, it allows to put a situation into perspective in its context, especially when the nature of the studied phenomenon is particularly rich and complex (Yin, 2018), and on the other hand, it allows to better understand an organizational change process (Halinen and Törnroos, 2005).

A single case was preferred to explore in depth the knowledge creation and sharing during a digital project. The number of partners in a supply chain and the richness of the studied relationships also explain the single case choice (Halinen and Törnroos, 2005). In addition, the conceptual framework –the SECI model– was mobilized to support the research and guide the empirical study. As single case, we selected Electra as it is a world-renowned industry manufacturer with headquarters in France and operating sites in approximately 60 countries. The Electra case is exemplary because it is based on a company of international stature, having deployed its supply chain 4.0 project on nine production sites in France and three other European sites, and on a network of 450 strategic suppliers located in Europe and Asia. This study focuses on the headquarters and 12 European sites and their international suppliers. Its production system is based on long cycles managing small series and requiring many high added value components. The suppliers are of various sizes (from SMEs to multinational companies), nationalities (French, from other European countries and Chinese) and technological maturities. Due to the complexity of products, Electra usually has long term relationships with their suppliers, and most have been working with Electra for more than five years.

We conducted semi-structured interviews with a project manager, a key user in a plant and the team project manager at the company’s headquarters. Four main themes were discussed during the interviews: the portal project, the use of the portal, the evolution of the procurement process and

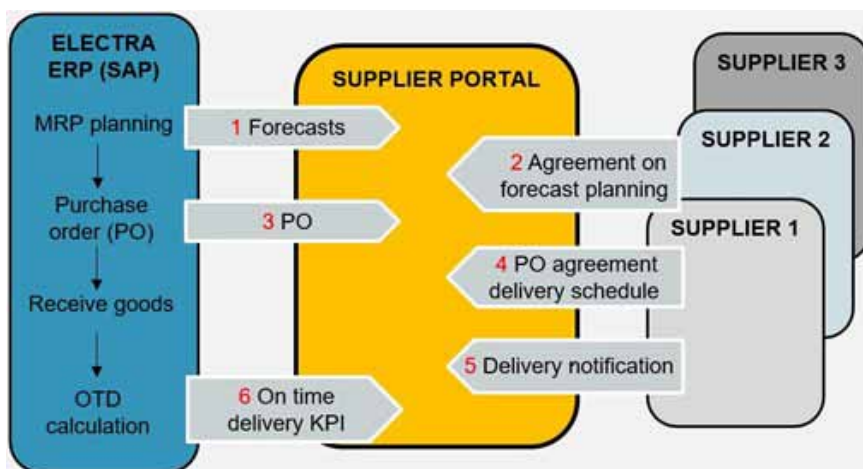
integration with ERP, and the evolution of collaboration. We also participated with Electra in their suppliers' survey, a questionnaire of 44 questions that addressed supplier use and integration of the portal, problems encountered, training and the quality of collaboration with the portal. A total of 134 suppliers answered the questionnaire (a 30% response rate), before interviewing two Electra suppliers to obtain additional information regarding some issues raised in the survey. Among those 134 suppliers, 12% had more than 1,000 employees, 25% had between 200 and 1,000 employees, 37% had between 50 and 250 employees and 25% under 50 employees, which gives a good representation of large, medium and small companies. Besides, we measured the supply chain information system maturity of the suppliers, 18% demonstrate a high level of information systems maturity, 58% a medium level and 24% a low level of information systems maturity.

In addition, we collected internal documents such as student dissertations, Electra training and communication documents, and web site information. By using different data sources, and following the recommendations of Yin (2018), we have sought to improve the validity and reliability of the information collected. The data collection was sequential. In the first step, we determined the project's history, its scope and the key challenges. In the second step, we analyzed the survey database, seeking to identify links between portal use by suppliers, the characters of the suppliers and their specific relationships with Electra.

CASE STUDY RESULTS

When Electra choose to adopt a supplier portal, the procurement process is at the center of this new digital project (see Figure 3). The project consists of digitalizing production forecast information, purchase orders and coordination of production, delivery schedules, delivery notifications and quality indicators (particularly the on-time delivery indicator). This project, led by a project manager from headquarters, aims to integrate almost all suppliers of technical components and to standardize the procurement process for the 12 involved sites. Electra uses the SAP ERP Central Component (SAP ECC) in-house, and the supplier portal deployed was also based on SAP technology (SAP Supply Network Collaboration), with the portal being customized and automatically integrated with Electra's SAP ECC. Suppliers can access the portal on a cloud platform via an internet connection and can extract data files from the portal. It took four years to implement the portal for all sites, all suppliers and all components.

Figure 3.
 Procurement process in Electra supplier portal



Phase 1: Initial Situation Before Portal Implementation

Most Electra procurement agents are experienced agents whose tacit knowledge of products, production lines and suppliers help them to conduct procurement process. They have used the SAP ERP for many years to edit material requirements planning (MRP) plans, create purchase orders and view inventory levels. They also communicate with suppliers about material plans and requirements, quantities and delivery dates, spending large amounts of time scheduling deliveries.

The communication tools used by Electra procurement agents usually consist of phone, fax, e-mails and non-standardized excel files. Electronic data interchange (EDI) exchanges have been implemented with a very small number of important suppliers for one or two transactions, but these are not expected to be generalized because of the low quantities at stake; moreover, EDI exchanges do not refer to forecasts. A supply chain manager summarizes the situation saying: *“procurement processes are 10 years late compared to other industries”* because they are not standardized and differ from one agent to another and from one Electra plant to another.

This phase presents a situation where mainly tacit individual knowledge is used in the procurement process and especially in dealing with relationships with suppliers. The experience of Electra procurement agents, their know-how and their personal relationships with supplier agents enable them to tackle scheduling issues. The organizational explicit knowledge is confined to SAP internal processes and no interorganizational explicit knowledge has been created. Thus, we observe here a typical socialization stage in the SECI model.

Phase 2: Portal Initiation-Adoption

When the portal project is launched by Electra, a project team is created with a central supply chain project leader and two pilot sites with project managers. The procurement process is formalized, and process rules are determined by the project team and called “Golden Rules”. For example, Golden Rule 2 states that “no requirement is made in the portal until Electra has signed the order line.” Electra is committed to comply with this rule and the supplier must confirm the deadlines within 48 hours.

The project team aims to get suppliers to adhere to the new tool. The suppliers are contacted by the project team, who present the new portal and the new rules and their consequences, either in a meeting with the supplier or in a web conference. A meeting report is then sent to the supplier that gives Electra’s approval for the supplier to use the portal. Finally, a new contract is signed. Communication about the new portal is settled. Internal communication about supply chain performance improvements underlines the time savings achieved and the better visibility and traceability of information. According to the project leader, the aim of the project is to formalize and standardize Electra’s supplier procurement processes for all actors and all plants.

In this phase, the need for explicit organizational and interorganizational knowledge is expressed. Codified, standard knowledge has been created by the project team and is diffused and communicated within Electra Company following a vertical hierarchy from top to bottom. For suppliers, formal communication about the portal and the new processes is initiated by the project team and leads to the signature of a new contract with the suppliers. We can identify this phase of this project as an externalization stage of the SECI model, which enables creation of organizational and interorganizational explicit knowledge from an initial situation (phase 1) in which tacit knowledge prevailed.

Phase 3: Portal Adaptation

First, the new portal is implemented in two pilot sites with chosen procurement agents. A first group of five suppliers, which have been selected because they are considered to be “collaborative” and “technology receptive”, test the new portal and new processes. At the end of this phase the project team question the five suppliers to obtain initial feedback about the portal and to improve some portal issues. For two years, the portal is extended to the 12 Electra plants, to most of the technical

suppliers, to most of the components and to different procurement processes. Each Electra plant forms a local team consisting of a project manager and a key user to accompany the local implementation.

For suppliers who have agreed the new contract, a supplier contact user is identified. Then, a one-day training session is organized with the supplier at an Electra plant. It consists of a plant tour to enable the supplier agents to visualize where the components they supply are used, an oral presentation, portal manipulations and delivery of paper documentation. In parallel, Electra procurement agents are trained on different scenarios that may appear during the process. A project manager insists on the importance of the collaborative relationship between the supplier user and their Electra procurement agent: *“The procurement agent has to play a real supporting role.”* During this phase, very close monitoring of new users (both internal and external) is undertaken by the local project team. On the one hand, they create precise dashboard indicators to follow system faults and on time transactions for procurement users and supplier users. On the other hand, they are present to answer questions, either on the premises or via a hotline for suppliers.

In this implementation phase, organizational and interorganizational knowledge is created and transferred, first in explicit forms: presentations with slides and training documents are made available to users; indicators are created by local teams to follow knowledge diffusion and to identify blocking points. Additionally, a tacit knowledge dynamic complements the explicit knowledge creation and transfer: users meet the project team, phone them, suppliers are received on plant premises and visit the project team, some suppliers meet other suppliers during training sessions and are supported in their use of the new portal by the procurement agent. A local project manager detailed: *“We took the time to explain to the suppliers the issues, the technical subtleties and to answer their questions. This helped to build trust.”*

This tacit knowledge creation transfer is desired and organized by the project team. It aims to enhance trust with suppliers, as they believe this to be a key factor for the portal project's success. The adaptation phase reveals issues that are central for the future routines and covers the combination stage of the SECI model. However, whereas combination mainly focuses on explicit knowledge being shared and coordinated in a system, Electra also develops interorganizational tacit knowledge sharing in parallel. Indeed, the project team believes that trust, participation and meeting with all stakeholders are essential for the success of this new knowledge system.

Phase 4: Portal Acceptance and Routinization

After the implementation phase has been finished, the local project manager is no longer necessary. The key user remains the only representative of the portal project in the Electra units, and they liaise with the portal project manager at headquarters. If, in some plants, the key user does not fulfill their role as system enabler and promoter, the system may be bypassed by users, for example by using Excel files. At the beginning of this phase, the portal project manager launches a quick survey sent to most suppliers using the system. One year later, another in-depth survey about extended use, integration and collaboration with the suppliers is sent to all suppliers using the portal; 134 answers have been analyzed, as indicated above (see the main results in Table 1).

A third survey issued two years after the full implementation of the portal points out several issues concerning suppliers: 45% of them still receive excel files in parallel with the system and sometimes must duplicate information, completing both these Excel files and the portal transaction. About 18% of respondents have not completed a training session on the portal, mostly because they have changed position. These new users have usually been coached by the previous user or have received a brief training session by telephone with an Electra key user: *“I didn't make training session and I use it every day, I think that it would be good to know some of key for more efficiency.”* Many users also reported difficulties with connection speed, vocabulary understanding “, cumbersome processes and quality of data. All survey respondents regularly use the basic portal functionalities but few of them make more advanced use of the portal. When the supplier agents encounter a problem when using the portal, only 21% first mention that they refer to training documents or procedures, whereas 61%

Table 1.
Main results of the supplier survey

	All firms 134			SMEs (staff < 200) 83			Large firm (staff > 200) 50		
Sample									
Digital maturity									
Own ERP	67%			61%			56%		
EDI with other customers	31.7%			28.9%			36.7%		
Other supplier portal	57.1%			58.5%			56%		
Number of portal connection in a month	mean 14.6			mean 14.19			mean 15.29		
Integration									
Portal forecast integration	72%			70.4%			76%		
Manual forecast integration	47.3%			49.1%			44.8%		
Excel forecast integration	46%			41.8%			52.6%		
Mtom forecast integration	5%			9.1%			2.6%		
Waiting for EDI implementation	12.6%			11.4%			14.9%		
Processes									
Training on the portal	81.2%			84.1%			76%		
Excel files in parallel with the portal	44.6%			41.3%			49%		
Collaboration									
Supplier for more than 5 years	86.5%			85.5%			87.8%		
Supplier for several plants	mean 5.2			mean 4.7			mean 6.16		
Increase of collaboration with Electra portal	Yes	Same as	No	Yes	Same as	No	Yes	Same as	No
Improvement of information quality	53.1%	29.5%	17.4%	56.1%	25.6%	18.3%	49%	34.7%	16.3%
Improvement of collaboration quality	50%	32.1%	17.9%	55.4%	25.3%	19.3%	42%	42%	16%
Considering as a member of the portal community	56%	–	44%	59%	–	41%	52%	–	48%
Waiting for portal improvement	71.3%	–	28.7%	72.8%	–	27.2%	68.1%	–	31.9%

phone Electra procurement agents: a supplier said: *“I prefer to call the procurement officer directly by phone to find a suitable deal.”*

Analyzing the survey results, we find no relationship between the size of the suppliers (small and medium enterprises or international groups) and the quality of portal acceptance (technical integration and quality of collaboration). However, those suppliers who have a low level of commitment with Electra and low technological maturity (around 35% of suppliers) use the portal *a minima* and bypass the portal with phone calls or excel files more frequently than other users. They criticize the new tool more frequently than others, and report missing the lost personal relationships: *“Since we work with the portal, we have lost contact and reactivity. Communication fails and commercial relationship weakens.”* In contrast, suppliers with either mature technological ability or a stronger commitment with Electra have developed integrated process with their own information systems and are positive about the quality of collaboration in the portal: *“It’s a good way to communicate with the customer, it avoids too many phone calls.”*

During this phase, the transfer of knowledge is being finalized and the sedimentation of interorganizational knowledge can be observed. We call this the internalization *stage*: users re-invest the interorganizational explicit knowledge created during the previous phases, by means of a learning by doing process. The key users can be considered as the major actors in this phase because they act as knowledgeable points of reference locally for Electra procurement agents and can be reached by phone by supplier users. When key users change or do not perform their role, the internalization stage faces more trouble in settling or gives way to diversions to the system. At Electra, no real communities of practice have been created, either within the company or with suppliers, that could take over if a key user should not perform their role. As a conclusion, Table 2 summarizes the proposed correspondences between the different phases of the project, the SECI stages and the interorganizational knowledge transformation observed in the Electra digital project.

DISCUSSION

Lancini (2015) characterized interorganizational knowledge and suggested that technology played an intermediary role between organizational knowledge management and interorganizational knowledge management. Moreover, in our literature review, we have referred to the common typology distinguishing tacit and explicit knowledge (Nonaka, 1994), which is particularly relevant in a supply

Table 2.
Synthesis of project role in Electra interorganizational knowledge creation

Project phases	SECI stages	Interorganizational knowledge
Initial situation phase No portal Legacy systems in each organization	Socialization Direct communication between actors No standard process	Tacit knowledge through bilateral exchange Bilateral and informal exchange between individuals of different partners
Adoption phase Portal choice Definition of new standard processes	Externalization Formalizing documents Interorganizational meetings New contracts with suppliers	Creating explicit organizational and interorganizational knowledge Creation of a common reference frame by the project team Communication from top to bottom
Adaptation phase Portal integration and new process implementation	Combination New technology tested Knowledge created by the project team has to be extended to all actors (internal and external)	Learning and sharing explicit interorganizational knowledge Multilateral exchanges within the organization and with suppliers Training sessions Creation of indicators for pilot implementation
Acceptation and routinization phase Portal usage and appropriation	Internalization Standard processes are transformed into routines Explicit knowledge is reinvested by individuals, transformed into tacit knowledge	Interorganizational knowledge for collaboration Users rely on the system to collaborate and share knowledge Some deviations may happen Key users are major players in this phase Project team uses surveys to collect feedback

chain context (Schoenherr *et al.*, 2014; Sudhindra *et al.*, 2020). The initial collaboration process shows a situation where only individual tacit knowledge highly related to persons is present. It is clear that the supply chain digital project enables the project team to create a real interorganizational knowledge shared by internal and external users and managers. The interorganizational vision is particularly significant in the context of global supply chains, since many partners will exchange information across geographic, linguistic and cultural boundaries. In the early 2000s, Shore (2001) noted that global supply chains raise major challenges for global information technology systems, suggesting appropriate data sharing strategies.

Furthermore, the new processes, rules, project documents and portal are the foundation of this new explicit knowledge while communication follows a hierarchical line from top to bottom when spreading in all plants. Whereas information systems are usually limited to this explicit knowledge creation and sharing, tacit knowledge also develop in such projects. Thus, a simultaneous dynamics originated by team project managers, key and final users, with phone calls, direct meetings and informal discussions, plays a counterpoint role with tacit knowledge still highly present to facilitate collaboration in the supply chain. However, in the context of global supply chains, it is important to consider misunderstandings in the exchange of tacit knowledge, linked for example to cultural differences that generate a major difficulty: the possibility of knowledge being expressed verbally in an understandable way (Collins, 2010). Thus, the more a supply chain 4.0 project involves partners from countries with different cultures, the more it will be necessary to think about the implementation of a global information system.

Despite the problems and deviations identified during the acceptance phase, the supplier portal has become a standard part of Electra's procurement process with its suppliers. Following the survey, the project manager wished to respond to the suppliers' feedback. On the one hand, training sessions on the advanced functionalities of the portal were provided to extend the use of such functionalities by the suppliers most committed to the portal, but on the other hand, a year later Electra implemented the capability for web-EDI in the portal so that some suppliers could automatically integrate data

form the portal in their own information system. Therefore, the continuous cycle of the SECI model seems to be continuing well in this case.

With the digital project, supply chain collaboration is evolving and becoming more structured. Initially informal, and based on interpersonal relationships, it gradually turns to formal (contract, written rules) and interorganizational collaboration in the adoption phase, then evolves towards hybrid forms with an intensification of relationships during the adaptation and acceptance phases. Thanks to this hybridization, a climate of trust can develop in which the new information system does not replace all inter-personal contact but allows for the fluidity and visibility of the information flow while serving as a support for the resolution of potential problems. It is therefore possible to conclude that the possible misunderstanding in the exchange of tacit knowledge within global supply chains finds an effective solution thanks to the progressive shift towards an explicit communication that reduces the problems of “translation” between partners.

THEORETICAL AND MANAGERIAL IMPLICATIONS

Based on the concept of interorganizational knowledge management, the case study aimed to explore the role of interorganizational information systems projects in the creation, sharing and transfer of knowledge within a supply chain 4.0 project. As mentioned, digitalization allows for the capture of massive amounts of information to improve the services provided and to offer new services to internal and/or external customers. It is therefore a major area of differentiation that can significantly improve the competitiveness of companies, and which requires in-depth investigation. To this end, reference was made in this article to the traditional typology that distinguishes between tacit and explicit knowledge, which seems particularly relevant in the context of supply chain management, and to use the SECI knowledge conversion matrix as a conceptual framework. The Electra case allows us to identify both theoretical implications for information systems management research, and managerial implications for companies involved in the formalization of a supply chain digital project.

Theoretical Implications

A lot of supply chain digital projects have not reached their objectives due to a lack of interactions, collaboration and commitment of the different partners (Choudhury *et al.*, 2021; Yang *et al.*, 2021). Following our case study results, we propose three proposals (P) that complement previous research on interorganizational knowledge in global supply chain contexts. They address the need for qualitative and longitudinal studies to better understand knowledge creation and sharing during the process of digital projects in supply chains:

- P1: *The implementation of a digital project contributes to the development of both tacit and explicit interorganizational knowledge in the supply chain.* While information systems linked to supply chain 4.0 project are generally considered to be limited to the creation and sharing of explicit knowledge (Frederico *et al.*, 2019), the case study points out that tacit knowledge is also created and shared in this type of project, sustained by the development of interorganizational collaboration during the different phases.
- P2: *The main phases of a digital project match the four stages of the SECI model.* The initial situation before the implementation corresponds to the socialization stage when mainly tacit knowledge is exchanged. The initiation and adoption phases of the project refer to the externalization process when contracts, standards, internal and external documents are formalized. In the adaptation phase, the combination of explicit knowledge and tacit knowledge in the learning and training experience enhances trust in the project and in the interorganizational collaboration. During the acceptance phase, internalization is represented by routines and possible deviations about the

digital technology in use. It also enables the supply chain to go on with the knowledge dynamics on other digital projects.

- P3: *Collaboration and trust are enhanced if the knowledge conversion process of the SECI model is carried out in a satisfactory way.* We confirm that “Ba” concept has a vital role for the success of SECI model (Wu, 2008; Canonico *et al.*, 2020; Borodako *et al.*, 2021); it extends it to the interorganizational context of supply chains. During the project social and interorganizational interactions are developed, which nurture future collaborations.

Managerial Implications

The literature review, the successes and failures of Electra digital project and the variety of involved partners in this case lead us to propose five recommendations for knowledge dynamics in a supply chain digital project. They concern five main points, relating to trust between partners, the centrality of tacit knowledge, the nature of communication, the selection of key users and the solutions to be offered to less committed partners:

- *Build trust relationships with partners.* We emphasize the importance of interorganizational context which refers to Nonaka and Konno’s (1998) “Ba” concept: building trust to ensure the achievement of these supply chain 4.0 projects is found to be highly important. The first underlying requirement for building trust and collaboration between partners is the existence of long-term relationships, as these projects typically last for quite a long time and investment in automation is financially costly. Furthermore, involving partners (suppliers in this case) in the creation of new processes, in the definition of new information, or in new knowledge sharing, consolidates trust and collaboration. Finally, the partner training sessions may serve to reinforce trust.
- *Don’t overlook tacit knowledge.* We have demonstrated in the Electra case that tacit knowledge plays a real role in the successful appropriation of the new technology. Focal companies should be aware of encouraging best practices, such as by inviting partner agents to receive training on the focal organization’s premises and to meet users from other organizations. In a project such as creating a supplier portal, maintaining good informal relationships between customer and supplier agents helps to build tacit knowledge and solve implementation issues more quickly.
- *Communicate both internally and externally.* Like for most information system projects, communication during the project is decisive to ensure project acceptance. External communication must not be underestimated because the focal firm needs to reassure its partners about the new technology, both before and after implementation. The practice of using partner surveys and meetings to collect feedback on the implemented information system enables the focal organization to improve their knowledge of the real use of the system and the settled routines that emerge. This can help the project team to upgrade the system and offer new functionalities.
- *Select appropriate key users.* While the project team should not last for the whole lifecycle of the new system, promoting key users and communities of practice can help for training new users and giving real assistance to agents who use this technology. Indeed, key users play a critical role as main facilitators of tacit knowledge internalization. We also believe that communities of practice (of key users), though not implemented in Electra, can prevent internal and external users from deviating from standard processes and bypassing the information system.
- *Offer simplified solutions for less committed partners.* We have highlighted the presence of partners, for example first-tier suppliers, with low technical maturity and lesser commitment to the focal firm. It would be worth proposing to this kind of partner a simplified interface that is easier to operate, with the presence of only main functionalities. This would help them to become accustomed to new digital technologies without intimidating them with complex tools they cannot manage.

CONCLUSION

Based on a longitudinal case analysis, this article has proposed a new link between the phases of a supply chain digitalization project and the stages of interorganizational knowledge creation based on the SECI model. It contributes to consider the temporality of the knowledge dynamics in digital projects with the methodology of a longitudinal case study, which is seldom used by scholars working on this subject. Based on the findings, the managerial implications consist in five recommendations for managers to support the various stakeholders of a supply chain digital project in building a favorable context and creating a knowledge dynamic to ensure the project success and to improve supply chain collaboration. These guidelines do not solely concern the implementation phase of the project, but also incorporate the post-implementation phase. In the long term, developing such a knowledge dynamic enables organizations to undertake auspicious new supply chain 4.0 projects (such as projects involving blockchain or predictive analytics) and to initiate new cycles of project development. The strategy of collaboration will only be possible if relationships between partners are based on a long-term vision and a climate of trust. Otherwise, the interorganizational exchange system risks being opportunistically bypassed by supply chain members.

However, the investigation has some limitations. First, we have relied on a single case for exploratory purposes, which allows us to make proposals, but makes any generalization delicate. Although Electra's relationships with its suppliers seem characteristic of many focal industrial customers with their suppliers, further studies should compare how the knowledge dynamics evolve in other digital projects and sectors. In addition, we did not study such parameters as cultural barriers that may affect the creation and sharing of knowledge. Finally, when we looked at the supply chain, we mainly studied the bilateral relationships between a focal customer and its suppliers, notwithstanding the other levels of the supply chain. Thus, it would be interesting for other studies to compare different digital projects configured to link several levels of the supply chain. The analysis, in a complex supply chain network, of the knowledge management processes across these projects could help determine whether an organization's place in the supply chain has an impact on the knowledge management processes, and if so, of what nature.

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COMPETING INTERESTS

The authors declare that there are no competing interests regarding the publication of this article.

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ENDNOTES

1 According to Stevens and Johnson (2016, p. 22), supply chain integration is “the alignment, linkage and co-ordination of people, processes, information, knowledge, and strategies across the supply chain between all points of contact and influence to facilitate the efficient and effective flows of material, money, information, and knowledge in response to customer needs”. From this point of view, integration does not refer to the nature of relationships between companies (adversarial vs. collaborative relationships), but rather to their ability of getting coordinated in order to improve the monitoring of logistical flows.

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