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# Towards Hyperconnected Supply Chain Capability Planning: Conceptual Framework Proposal

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**Abstract:** *This paper is to drive research towards a methodology that will enable organizations to foster high performance when planning their supply chain capabilities in the Physical Internet (PI) era. It first introduces the relevant concepts to understand the specificities of performing Supply Chain Capability Planning (SCCP) in the PI era and deduces two enablers: hyperconnectivity and automation. Second, it assesses the relevance of the Sales and Operations Planning (S&OP) methodology to perform SCCP in the PI era and concludes that it would not be sufficient. Consequently, it third introduces the Hyperconnected Supply Chain Capability Planning (HSCCP) methodology and the associated conceptual framework proposal, aiming to fill the gaps left by the S&OP methodology to perform SCCP in the PI era. It finally concludes leading the limitations of this paper towards avenues for future research.*

**Keywords:** *Hyperconnectivity, Physical Internet, Supply Chain Capability Planning, Sales and Operations Planning, Integrated Business Planning, Information Systems, Decision Support Systems, Automation, Agility, Logistics Network.*

## 1 Introduction

An organization may have multiple strategies to be competitive. When the organization's strategies are established, it must make plans to drive its future. Depending on their granularity and planning horizon, these are often categorized as strategic plans for the forthcoming years, and tactical plans for the forthcoming months. A common methodology used by organizations to build and manage these plans is called Sales and Operations Planning (S&OP) (Ling and Coldrick, 2009; Ling and Goddard, 1988). The main objective of the S&OP methodology is to drive organization's teams towards a set of plans (sales, marketing, development, manufacturing, sourcing, and financial) aligned with the strategy and coherent between each other. Another name more recently introduced is Integrated Business Planning (IBP), which basically corresponds to the S&OP methodology when the implementation has reached a certain level of maturity (Bower, 2012). Thus, only the term S&OP will be used throughout this paper.

Since the Physical Internet (PI) was introduced (Montreuil, 2011), it gained significant attention from both the academic and practitioners communities (Treiblmaier et al., 2016). The PI is to design an open global logistics system that enable to manage logistics flows (material, information and money) in a way inspired from the way the digital internet deals with data flows (Montreuil et al., 2012). Simmer et al. (2017) highlighted the importance for supply chain actors to collaborate when planning their activities in the PI era, giving the S&OP process as an example of planning activity. It concluded with the need for future research in solutions to support collaboration in the PI era, highlighting the information system aspect.

This paper focuses on supply chain planning in the PI era and has a double purpose: the first is to highlight the limitations of the existing S&OP methodology and associated information systems to foster high performance in the PI environment. The second and main purpose of this paper is to introduce the foundation stone for a new methodology taking advantage of the PI paradigm: Hyperconnected Supply Chain Capability Planning (HSCCP).

The paper first positions the relevant concepts of Supply Chain Capability Planning (SCCP), the PI, and hyperconnected supply chains. Second, it provides a systematic review of S&OP, with a focus on associated information systems to support decisions and its usability in a PI environment. Based on the systematic review, limitations are identified regarding the S&OP methodology to perform in the PI environment. Third, it introduces the proposed Hyperconnected Supply Chain Capability Planning (HSCCP) methodology and associated conceptual framework. Finally, the paper provides insights for industry and avenues for future research regarding HSCCP.

## **2 Background and research statement**

As indicated by its name, the proposed HSCCP methodology that will be introduced in section 4 suggests making business planning revolve around supply chain capabilities. In addition, it is designed to perform with hyperconnected supply chains of the PI era. So, this first section is to first position the relevant concepts of supply chain capability planning, the physical internet, and hyperconnected supply chains. Second, it is to identify Supply Chain Capability Planning (SCCP) enablers to perform in the PI era.

### **2.1 Physical Internet, hyperconnectivity, and supply chain capabilities**

First, the Physical Internet has been introduced by Montreuil (2011) and defined as a hyperconnected global logistics system enabling seamless open asset sharing and flow consolidation through standardized encapsulation, modularization, protocols and interfaces (Montreuil, 2015; Montreuil et al., 2013). As expressed by Montreuil (2015), it is said to be hyperconnected as its components (agents, containers, facilities, etc.) are intensely interconnected on multiple layers, ultimately anytime, anywhere. The interconnectivity layers of the PI notably include digital, physical, operational, business, legal and personal layers. The network of stakeholders being part of the PI system is referred as the logistics web. Montreuil et al. (2013) describes this logistics web as a network of openly interconnected logistics networks and service providers.

Second, putting aside several references from the field of mathematics and biology, the oldest use of the term hyperconnectivity about information systems interconnection that has been found was by Quan-Haase and Wellman (2005). Focusing on computer mediated communication, Quan-Haase and Wellman (2006) define the hyperconnectivity as “the availability of people for communication anywhere and anytime”. In this paper, the supply chain hyperconnectivity must be understood as the availability of supply chain stakeholders’ information systems for communication anywhere and anytime (i.e. the availability of the information shared by all supply chain stakeholders, anywhere and anytime). Consequently, we get back to the definition of the hyperconnectivity in the PI, as availability of the information shared by all its components, anywhere and anytime.

Third, a supply chain capability of a PI stakeholder (private logistics network or individual organization) is defined as the combination of an ability (i.e. know-how) and the associated capacity that contributes to the utilization of this ability (i.e. the availability of the required resources). For example, an organization could have the capability of producing a specific smart

and modular PI containers. This capability would be made possible by having the ability (i.e. the know-how) to produce it; and by having the corresponding capacity that could be deduced from the availability of the equipment needed to produce it plus the availability of the people having the right skills to use this equipment. Figure 1 illustrates the definition of supply chain capabilities. A capability as seen by other stakeholders of the PI logistics web can correspond, from the capability owner viewpoint, to a combination of more than one internal ability and associated capacity (i.e. sub-capabilities). This depends on the granularity of the information a stakeholder wants to share about its capabilities. Consequently, from the given definition of a supply chain capability, this paper defines Supply Chain Capability Planning as the activity of planning abilities and associated capacities. For an organization, the objective of SCCP is to make decisions about what to do in the future regarding the capabilities it already has and the one it could need. Decisions about organization's capabilities can be either to provide it internally, to outsource, both, or even not providing it. For example, when an organization absolutely needs a new capability it must choose between investing in developing the corresponding ability and acquiring the corresponding resources, or outsourcing the capability, or both. Another example, when an organization needs more capacity about a capability it already has in order to meet the increasing demand, it must choose between investing in more capacity, outsourcing this additional capacity, both, or even not meeting the demand.



*Figure 1: Definition of the supply chain capabilities as the combination of supply chain abilities and the associated supply chain capacities that contributes to the utilization of these supply chain abilities.*

## 2.2 Enablers to perform supply chain capability planning in the Physical Internet era

The dynamicity of today's supply chain environment is constantly increasing, the supply chain environment is changing at such pace that organizations can struggle to keep track and respond to the evolutions (Harrington et al., 2010). For example, on strategic planning, Melnyk et al.(2014) considers that reviewing supply chain design every 5–10 years is no longer adequate and that dynamic reconfiguration is needed. In addition, as mentioned in the previous subsection, the PI implies the hyperconnection of all its components and so all its stakeholders (Montreuil, 2015). So, it would enable PI stakeholders to access and share information about their supply chain environment anywhere anytime. Combining both these elements, the hyperconnection and the dynamicity of the supply chain environment, leads us to PI stakeholders hyperconnected to a fast-changing supply chain environment they must deal with. But organizations cannot manually manage such amount of dynamic information, and so could not take all of it into account when making decisions about their supply chain capabilities plan. Therefore, a solution to enable PI stakeholders to consider all relevant information into account when making decisions about their supply chain capabilities plan would be the automation of as much SCCP analysis as possible. Automation to enable to consider the high volume of information, and to enable to keep track of the fast-changing information.

Finally, this subsection identified the following two enablers to perform SCCP in the PI era:

1. Hyperconnectivity, to make information about PI stakeholders available anywhere and anytime (being intrinsic to the PI definition).
2. Automation, to deal with high volume of fast-changing information.

## 2.3 Research Statement

The two preceding subsections positioned the background defining important concepts and identifying enablers to perform SCCP in the PI era. It leads to the following two research questions that structure this paper:

1. Are traditional SCCP methodologies as Sales and Operations Planning (S&OP) appropriate to perform in the PI era?
2. If the answer to the first question is “no”, what would be the evolutions needed to design an appropriate methodology?

The following two sections are structured according to both these research questions.

## 3 Is the Sales and Operations Planning methodology appropriate to perform in the Physical Internet era?

This section is to identify if organizations could use Sales and Operations Planning (S&OP) to plan their supply chain capabilities in the Physical Internet (PI) era. The first subsection gives an overview of the S&OP methodology and to what extent it enables organizations to plan their supply chain capabilities. Then, the second subsection challenge the S&OP methodology according to the Supply Chain Capability Planning enablers to perform in the PI era.

### 3.1 Sales & Operations Planning

To start with S&OP, the following quote from the S&OP definition of the APICS dictionary gives an overview of the purpose of S&OP (Blackstone and Jonah, 2013):

“A process to develop tactical plans that provide management the ability to strategically direct its businesses to achieve competitive advantage on a continuous basis by integrating customer-focused marketing plans for new and existing products with the management of the supply chain. The process brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, and financial) into one integrated set of plans. S&OP is performed at least once a month and is reviewed by management at an aggregate (product family) level. The process must reconcile all supply, demand, and new product plans at both the detail and aggregate levels and tie to the business plan. It is the definitive statement of the company's plan for the near to intermediate term, covering a horizon sufficient to plan for resources and to support the annual business planning process.”

S&OP was created back in 1984 by Richard (Dick) Ling (Ptak and Ling, 2017). Its first appearance in the literature was in 1988 within the book ‘Orchestrating success: Improve control of the business with sales & operations planning’ (Ling and Goddard, 1988). The S&OP process proposal made in 1988 was then updated in 2003 and 2009 (Coldrick et al., 2003; Ling and Coldrick, 2009), Figure 2 illustrates this latter S&OP process proposal. Three main changes were emphasized between the first proposal and the latter: First is the appearance of an emphasis on alignment. The alignment of all the plans (sales, marketing, development, manufacturing, sourcing, and financial) with the business strategy, shifting from a left to right unidirectional process to a bidirectional process that explains the process loops illustrated in Figure 2. This alignment with the business strategy is represented by the arrows from the senior

business management review activity to the three following activities: managing new activities, managing demand, and managing supply. Depending on this business strategy, teams will focus on different Key Performance Indicators (KPIs) to make decisions about these plans. Second is the addition of a step to consider managing new activities in addition of the existing portfolio. Third is the shift from a linear process to a process centered on integrated reconciliation. The integrated reconciliation step is to ensure the coherence between all the plans, and to take into consideration their interdependencies (Ling and Coldrick, 2009; Piñón, 2017). This integrated reconciliation is represented on Figure 2 by both the big arrow containing this term and the arrows between the three following activities: managing new activities, managing demand, and managing supply. Four structural categories of components are identified from the descriptions of the S&OP methodology: first, the stakeholders who are undertaking each activity of the S&OP process. Second, the information sharing principles that feed each activity with the needed information. Third, the information usage that corresponds to the completion of each activity. Fourth, the activities frequency that depends of the frequency of the S&OP process loop.

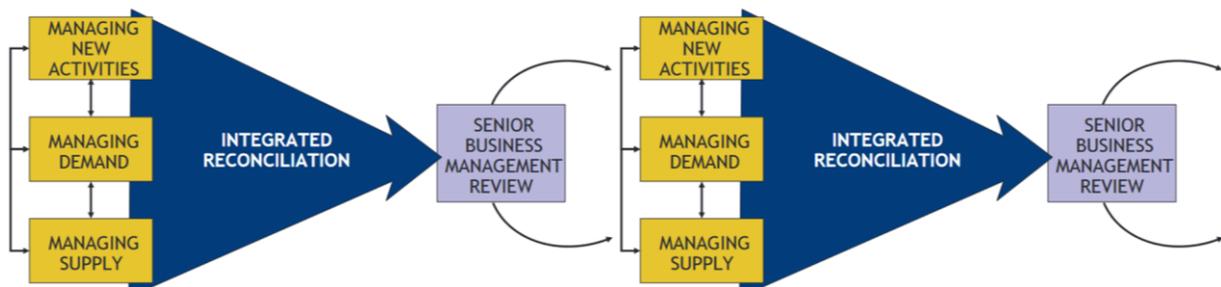


Figure 2: Sales and Operations Planning process (adapted from Coldrick et al. (2003))

As previously mentioned, the definition of the S&OP methodology suggests driving business decisions through the creation of several plans for the business. Implementing these plans include important business decisions such as asset investments and location (e.g. facilities, equipment, human resources, and inventories), asset allocation (e.g. human resource, and financial), partnerships (e.g. suppliers and subcontractors selection), core asset maintenance scheduling (e.g. planning maintenance according to production needs), promotion scheduling (e.g. planning promotions according to anticipated extra capacity of resources), product portfolio and associated priorities (e.g. deciding whether or not launching a new product), and product design and technology choices (e.g. to design a product considering its impact on the supply chain). All these decisions concern the internal supply chain capabilities of the business. It is all about planning the supply chain capabilities and actions that relies on these supply chain capabilities, to fit the business strategy (Lapide, 2004; Ling and Coldrick, 2009).

### 3.2 Limitations of the Sales & Operations Planning methodology to perform in the Physical Internet era

To create the plans recommended by the S&OP methodology, organizations must implement a process enabling them to manage the information needed to create these plans. From a high-level perspective, the S&OP methodology gives guidelines on how to organize this process. However, Tuomikangas and Kaipia (2014) highlighted that companies lack guidelines and advice about how to implement S&OP. An emphasis is made on technological solutions, saying that the literature on technological proposal to support S&OP is still in its early stage. Tuomikangas and Kaipia (2014) conclude that conceptual and empirical literature on technological solutions to support S&OP deserves future research with a new type of thinking and process design covering strategic business targets. In addition, all S&OP maturity models

analyzed to write this paper point out that information technology plays a key role to reach high-level of S&OP maturity (Cecere et al., 2009; Grimson and Pyke, 2007; Lapede, 2005; Viswanathan, 2010; Wing and Perry, 2001). Tavares Thomé et al. (Tavares Thomé et al., 2012) and Tuomikangas and Kaipia (2014) did the same observation that advanced information systems are viewed as essential to align strategies and operations when moving towards advanced S&OP stages. Consequently, the combination of both these previous elements, the importance of information technology solutions to reach high S&OP maturity and the lack of literature on it, show a gap in the S&OP literature.

A major obstacle for organizations to use S&OP to plan their capabilities in the PI era comes out bringing together the following two elements: first, the gap of information technology solutions to support S&OP. Second, the Supply Chain Capability Planning (SCCP) enablers identified in the second section being hyperconnection and automation. The S&OP literature does not provide information technology solutions neither for the hyperconnection requirement to make information about PI stakeholders available anywhere and anytime, nor the automation requirement to deal with high volume of fast-changing information. Therefore, the current S&OP literature does not provide solutions to perform SCCP in the PI era.

#### 4 A proposal for organizations to perform Supply Chain Capability Planning in the Physical Internet era: Hyperconnected Supply Chain Capability Planning

This section is to introduce a proposal for organizations to perform Supply Chain Capability Planning (SCCP) in the Physical Internet (PI) era: Hyperconnected Supply Chain Capability Planning (HSCCP). The HSCCP conceptual framework proposal introduced in this section aims to be the foundation stone that describes the mains concepts of the HSCCP methodology, and how it approaches SCCP to fill the gaps identified with the S&OP methodology. It is composed of three main structural concepts (Figure 3) inspired from the four that were identified in the description of the Sales and Operations Planning (S&OP) methodology: first are the stakeholders, second are the information sharing principles, and third are the information usage principles. These three HSCCP concepts are described in the three following subsections. The fourth element, frequency, identified in the description of the S&OP methodology were not kept for the HSCCP. Because it is considered as part of the information sharing and information usage through the hyperconnection and dynamicity principles that will be introduced.

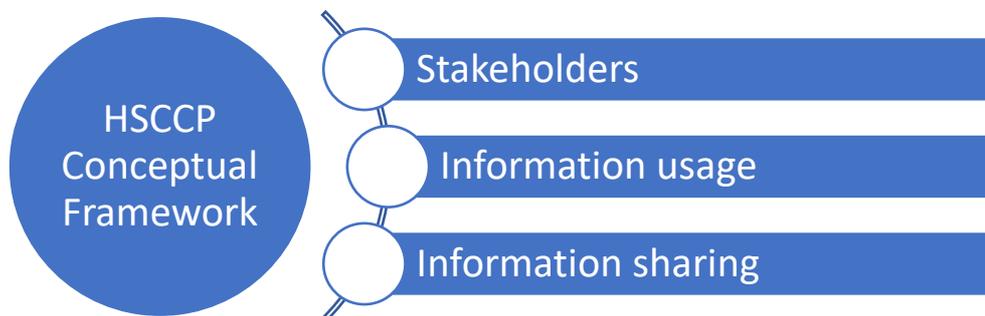


Figure 3: Main structural concepts of the Hyperconnected Supply Chain Capability Planning conceptual framework proposal

##### 4.1 HSCCP Stakeholders

There are two levels of HSCCP stakeholders. First is the network level, it corresponds to the entities providing supply chain capabilities across the PI network. The rest of the paper will

refer to these entities as PI stakeholders, it can be entities such as individual manufacturing companies, haulage contractor, or private logistics networks. Second is the private level, it corresponds to the internal organization of a PI stakeholder, teams that are involved in the HSCCP. The list of these internal teams has been taken from the S&OP methodology: sales, marketing, development, manufacturing, sourcing and finance teams. The rest of the paper will refer to these private level stakeholders as internal stakeholders. These two levels of HSCCP stakeholders are illustrated in Figure 4. Note that in some cases such as private logistics networks, an additional intermediate level within the private level might be to consider.

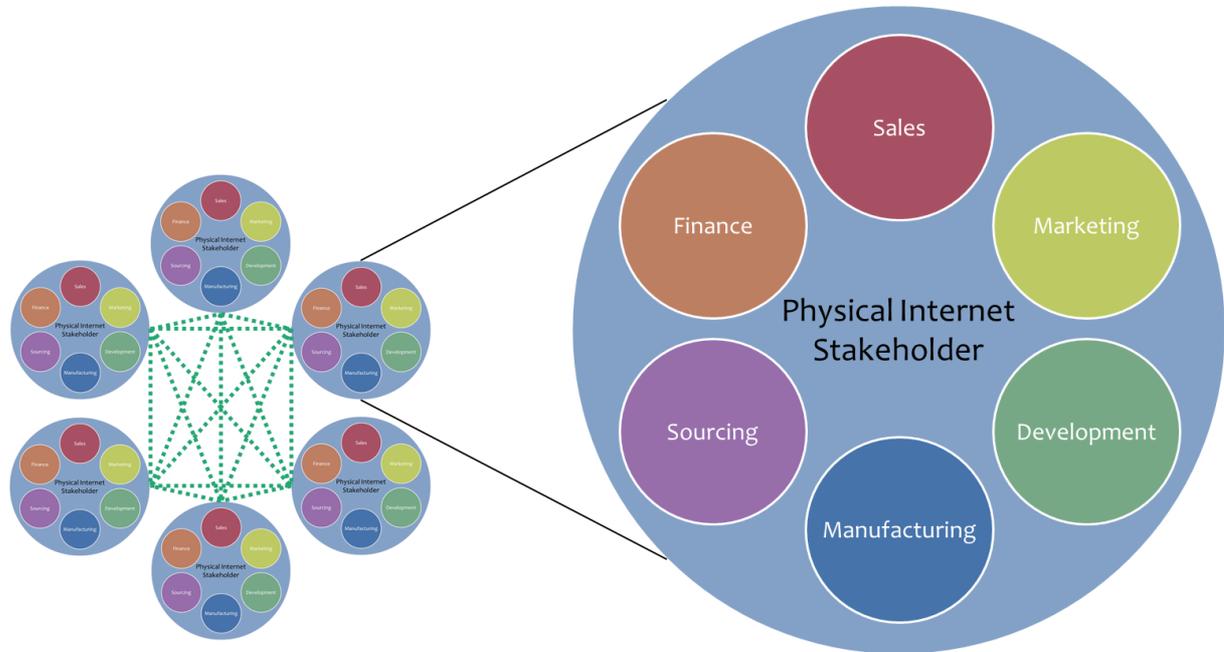


Figure 4: Illustration of the two levels of stakeholders considered for Hyperconnected Supply Chain Capability Planning: the network level (PI stakeholders) and the private level (sales team, manufacturing team, etc.)

## 4.2 HSCCP information sharing principles

HSCCP information sharing is based on two elements: first is communication and second is information. These two elements are described within the following two subsections.

### 4.2.1 HSCCP communication principles

The communication solution must support the following principles: openness, hyperconnection, data privacy, and modularity. The first two principles, openness and hyperconnection, are to give to every single organization the ability to communicate anywhere anytime. The third principle, data privacy, is one of the pillars of communication technologies. To reassure organization about it, communication security must be ensured. In addition, organizations must be able to choose to what extent they will share information. Indeed, the fourth and last principle, modularity, is to ensure information sharing modularity through the possibility to establish modular information sharing policies and contracts.

### 4.2.2 HSCCP information flows

Bringing together the previously given definitions of SCCP and hyperconnectivity, Figure 5 illustrates the main categories of information flows to perform HSCCP from the point of view

of a PI stakeholder. It contains two types of information flows, both being necessary to perform SCCP: the first is external information sharing, corresponding to information shared with other PI stakeholders and information received from other PI stakeholders. The second is internal information about objectives and capabilities.

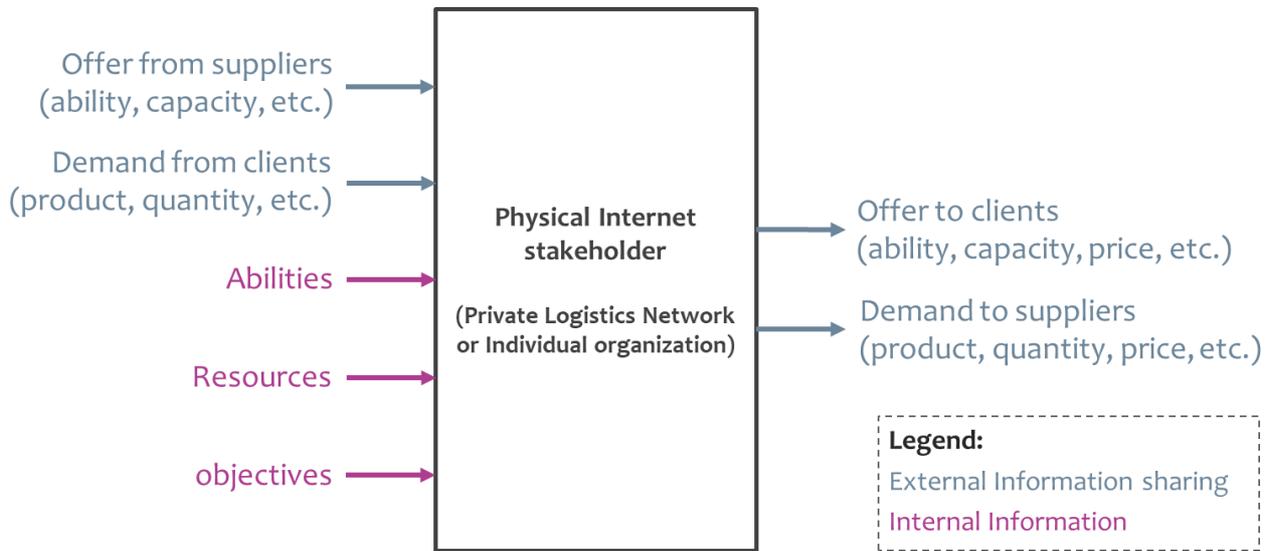


Figure 5: Illustration of the main information flows for Hyperconnected Supply Chain Capability Planning, as seen from the viewpoint of a Physical Internet stakeholder

### 4.3 HSCCP information usage principles

The hyperconnectivity opens the way for organizations to rethink the way they manage their SCCP activities, and the HSCCP proposal intend to take advantage of it. This subsection is to explain how the HSCCP methodology suggests to organizations to rethink the way they manage their SCCP activities, assuming the information sharing principles described in the previous subsection are satisfied. Figure 6 illustrates the essence of how the HSCCP methodology proposal suggest rethinking the way organizations use information to plan their supply chain capabilities. It is considered as the core of the HSCCP methodology proposal and so is presented as the main illustration of the HSCCP conceptual framework. This HSCCP conceptual framework is built around the principle of agility and dynamicity. The idea is to make SCCP as dynamic as the supply chain environment. It has been divided into two objectives inspired from the definition of agility suggested by Barthe-Delanoë et al. (2014, 2018): first, on the left part, is the dynamic detection of evolutions that impact supply chain capability plans. Second, on the right part, is the dynamic adaptation of supply chain capability plans to evolutions. Both these objectives are related, the second one relying on the outcomes of the first one. Both these objectives are similarly decomposed in three types of sub-objectives: detection, assessment, decision. They will both be explained in the following paragraphs.

The first objective, dynamic detection of evolutions that impact supply chain capability plan, relies on the information sharing principles to get information from PI stakeholders and internal stakeholders. It is to provide the second objective, dynamic adaptation of supply chain capability plans to evolutions, with the information that according to the detected supply chain environment evolutions it could be needed to adapt the supply chain capability plans. This first objective is composed of the three following sub-objectives: first is the detection of evolutions, it corresponds to detecting evolutions in the supply chain environment coming from other PI stakeholders as well as internal stakeholders. Second is the impact assessment of evolutions, it corresponds to assessing the impact of the detected evolutions on the supply chain capability plans. Third is the deduction of potential needs for adaptation, it corresponds to deducing

potential needs for adaptation of the supply chain capability plans considering the detected supply chain environment evolutions.

The second objective, dynamic adaptation of supply chain capability plans to evolutions, is triggered according to the first objective outcome. It is only triggered if the outcome of the first objective is that there are potential needs for adaptation of the supply chain capability plans. It is to make decisions about potential changes in the supply chain capability plans considering the detected supply chain environment evolutions. This second objective is composed of the three following sub-objectives: first is the identification of adaptation alternatives, it corresponds to identifying the set of possible supply chain capability plans alternatives to adapt to the detected supply chain environment evolutions. Second is the performance assessment of adaptation alternatives, it corresponds to assessing the performance of the supply chain capability plans adaptation alternatives. It must enable the evaluation of supply chain structural changes. Third is the decision of the adaptation alternative to implement, it corresponds to deciding about the supply chain capability plans to implement, relying on the assessment of the adaptation alternatives, to adapt to the detected supply chain environment evolutions.

Looking towards functional and technological solutions, to reach these conceptual framework objectives built around the principle of dynamicity, the solution must satisfy, at least partially if not entirely, the two SCCP enablers identified in the second section of this paper: hyperconnectivity and automation. The conceptual framework has been designed in this sense.

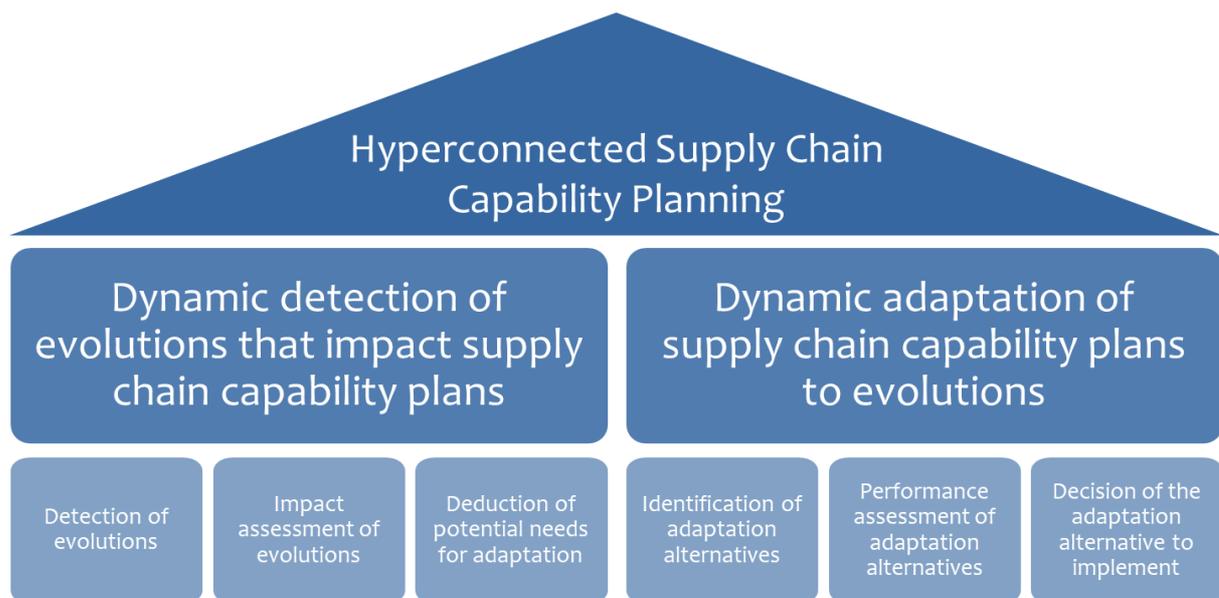


Figure 6: Core of the Hyperconnected Supply Chain Capability Planning conceptual framework

## 5 Conclusion and avenues for future research

This paper is to support the realization of Supply Chain Capability Planning (SCCP) in the Physical Internet (PI) era. It first introduced the relevant concepts to understand SCCP and the specificities of the PI era, and it deduced two enablers to perform SCCP in the PI era: hyperconnectivity and automation. Second, it assessed the relevance of the Sales and Operations Planning (S&OP) methodology to perform SCCP in the PI era. It concluded that the S&OP methodology as it currently exists would not be enough to perform SCCP in the PI era. The S&OP literature does not provide information technology solutions or guidelines neither for the hyperconnection nor the automation requirements. Consequently, the need for a methodology filling these gaps was highlighted. Therefore, it third introduced the

Hyperconnected Supply Chain Capability Planning (HSCCP) methodology proposal with its conceptual framework. This HSCCP methodology aims to fill the previously mentioned gaps of the S&OP methodology to perform in the PI era.

The study presented in this paper has some limitations that are important to keep in mind. First, only the S&OP methodology (also known as Integrated Business Planning) has been analyzed and challenged because it was considered as the most common methodology used by organizations to perform SCCP. It would be beneficial to have the same approach for methodologies such as Collaborative Forecast and Replenishment (CPFR) and Adaptive S&OP. Second, Supply Chain Risk Management (SCRM) was not mentioned in the study, it could be interesting to integrate it within the conceptual framework. An additional research avenue would be the completion of this HSCCP conceptual framework proposal going more in depth into the description of each element.

Finally, the HSCCP conceptual framework described in this paper could be part of a set of three frameworks to fully design the HSCCP methodology proposal: First, the conceptual framework describing the main concepts of the HSCCP methodology and how it approaches SCCP. Second, a functional framework to describe how this methodology can be used by organizations and their teams to plan their supply chain capabilities. Third, a technological framework to describe how information technology can meet the expectations and challenges of the conceptual and functional frameworks. All together these three frameworks are to give a full description of the HSCCP methodology, giving organizations enough information and guidelines to implement it.

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