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Enabling Supply Chain Agility and Resilience Improvement: Toward a Methodology and Platform

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Abstract: Our research ambition is to provide businesses with a methodology and platform able to guide them towards the improvement of their *logistics network* in terms of *agility* and *resilience*, and so of their overall supply chains performances. To minimize the efforts that businesses will have to provide, our methodology will enable the platform to automate the recommendations for *logistics network* performance improvements in terms of *agility* and *resilience*. To fulfil this ambition, we are combining two research projects: the Physical Internet Initiative and the IO-Suite project.

Keywords: Logistics Network, Supply Chain, Agility, Resilience, Physical Internet, Decision Support Systems, Information Systems, Modeling, Simulation.

1. INTRODUCTION

Our research ambition is the result of the combination of businesses requests and two complementary research projects: the Physical Internet Initiative ("Physical Internet Initiative," n.d.) and the IO-Suite project ("IO-Suite Home," n.d.). The project is structured according to two main aspects: a business aspect including the *logistics network* representation, and an information system aspect including information technologies and methodologies. The Physical Internet (PI) framework (Montreuil et al., 2013) is the starting point for our business (logistics network) perspective, and the IO-Suite methodology (Benaben et al., 2014) is the starting point for our information system perspective.

The Physical Internet Initiative has the objective "to enable an efficient and sustainable Logistics Web" through "an open global logistics system founded on physical, digital and operational interconnectivity through encapsulation, interfaces and protocols" (Montreuil et al., 2013). In other words, it is aimed to meet the Global Logistics Sustainability Grand Challenge (Montreuil, 2011). On his side, the IO-Suite project (encapsulating the concept of MISE: Mediation Information System Engineering) focuses on supporting the interoperability of collaborative networks (Benaben et al., 2014). To support the collaborative situation, the IO-Suite project uses a model-driven engineering approach to design a service-oriented MIS (Mediation Information System). At this time the IO-Suite project was mainly focused on the humanitarian crisis management (Benaben et al., 2015). So, we want to spread and adapt the methodology to the Supply Chain Management (SCM) field.

2. RESEARCH LITERATURE AND LIMITATIONS

The literature on Supply Chain Management is very broad and includes several disciplines. In addition to the PI and the MISE, we are focusing especially on the following ones: Supply Chain Design and Supply Chain Optimization.

Literature reviews have shown that researchers have been working on these domains for a long time. Here are literature reviews we considered: Vidal and Goetschalckx (1998), Meixell and Gargeya (2005), Power (2005), Swafford et al. (2008), Arzu Akyuz and Erman Erkan (2010), Klibi et al. (2010). Some aspects are already up and running, as deterministic supply chain mathematical optimization models including one or several parameters (Linear Programming, Mixed Integer Linear Programming, etc.). However, there are still a lot of ongoing researches on this domain because of a huge and almost incommensurable amount of factors that influence the supply chain. Vidal and Goetschalckx (1998) said: "It is almost impossible to develop a general, single model that integrates all these aspects", "Most uncertainties are not considered", and International factors are not fully described by the existing models. Meixell and Gargeya (2005) confirm these observations by saying that the consideration of the complexity of international supply chains makes difficult the use of mathematical models for global supply chain optimization.

Most of these first examples are focusing on efficiency optimization, as for example cost optimization. It is only quite recently that researchers started to focus on some other aspects of the supply chains performances as the agility and resilience. We should note that other supply chain performance criterions are also considered in the literature, as flexibility, adaptability, and robustness. Power (2005) affirms that a successful implementation of collaborations between businesses (processes, relationship and technology) becomes a competitive advantage. He completes saying that the inter-dependence of all partners in a supply network appears to be an important pre-cursor, and suggests to formalize the strategies to better manage this collaborations. Also highlighting business competitively, Swafford et al. (2008) propose a conceptual framework for supply chain agility and flexibility. However, they only focus on internal supply chains from one company perspective. On their side, Arzu Akyuz and Erman Erkan (2010) focus on a performance measurement review and mention that one of the challenges is the difficulty in measuring the degree of collaboration, agility and flexibility. One of their guidelines identified about future research perspectives is the need for performance measurement method, metrics, and tools for responsive supply chains and collaborations. Finally, Klibi et al. (2010) made a critical review on the design of supply chain networks focusing on the design under uncertainties and on the three following performance criterions: robustness, responsiveness and resilience. One of their conclusions is that capturing the essence of the real supply chains problematics is quite complex and that there are still a lot of research to carry out in this domain. To complete our literature analysis, we considered a more recent literature reviews on each of the two performance criterions: agility (Fayezi et al., 2015, 2016) and resilience (Christopher and Peck, 2004; Kamalahmadi and Parast, 2016). We identified that there are no real consensus on the definitions of the agility and resilience performance criterions. So, considering the several definitions within the research papers mentioned previously, we will propose in this paper definitions adapted to our vision and mainly based on the following definitions we selected. Fayezi et al. defined the supply chain agility as "a strategic ability that assists organizations rapidly to sense and respond to internal and external uncertainties via effective integration of supply chain relationships". Kamalahmadi and Parast defined the resilience as "the adaptive capability of a supply chain to reduce the probability of facing sudden disturbances, resist the spread of disturbances by maintaining control over structures and functions, and recover and respond by immediate and effective reactive plans to transcend the disturbance and restore the supply chain to a robust state of operations".

2. RESEARCH PROPOSAL AND AGENDA

2.1 Research Proposal

Our research proposal focus is at the intersection of the supply chain design (we will introduce the broader concept of *Logistics Network* design), supply chain optimization, and supply chain performance measurement (with a focus on agility and resilience) fields. We want to answer the following supply chain challenges identified in the previous section: first, we want to enable the measurement of the degree of agility and resilience for *logistics networks*. Secondly, we want to de design a methodology enabling the deduction of recommendations for strengthening actions to improve these *logistics network* performance in terms of agility and resilience. Finally, we want a methodology and a platform enabling as much automation as possible. The scope of the decision support system we propose is, at this time, limited to the strategic and tactic business levels because it is aimed to support strategical and tactical decisions. As mentioned in the introduction, in order to fulfil this ambition, we are taking advantage of two research projects: the Physical Internet Initiative and the IO-Suite project.

2.2 Research Agenda

Our research agenda is organized accordingly to the methodology we are designing to guide businesses towards the improvement of their *logistics network* in terms of *agility* and *resilience*. We describe the different steps of our methodology in the following sub-sections.

2.2.1 Logistics Networks Modeling

The first step of our methodology corresponds to the modeling of logistics networks. This modeling step is needed in our methodology to represent *logistics networks*, in order to allow the information system to use this information for deductions, simulations, and recommendations at strategical and tactical business levels.

We define a *logistics network* of an entity (company, group of companies, etc.) as the network of all partners known by this entity and available to work with it. This concept is based on the more global concept of *logistics web* described in the Physical Internet framework and defined as "a web aiming to serve logistics needs of people, organization […] that is both open and global" (Montreuil et al., 2013). So, as Montreuil et al. did for the logistics web, we describe the *logistics networks* through five constituents: *mobility network*, *distribution network*, *realization network*, *supply network*, and *service network*. In addition, we will consider the SCOR framework (Stewart, 1997) for the representation of the supply chains interactions. The last version of this SCOR Framework defines the six following processes categories: *Plan*, *Source*, *Make*, *Deliver*, *Return*, and *Enable* ("SCOR Framework - The APICS Supply Chain Council," n.d.). Based on both these *logistics networks* components categories, we are designing a *logistics network metamodel* which will structure these models in a standard way of representation. To design this metamodel, we will take advantage of the work done by Bénaben et al. (2016) who build a metamodel for knowledge management in the crisis management context.

Considering our Logistics Network definition and literature review, we will consider the following definitions for Logistics Network agility and Logistics Network resilience:

- Logistics Network agility: the ability of the Logistics Network to rapidly sense and respond to internal and external changes.
- Logistics Network resilience: the ability of the Logistics Network to reduce the probability of facing disturbances, to minimize the spread of disturbances, and to rapidly restore the supply chains to a robust state of operations.

2.2.2 Available Supply Chain Processes Deduction

This second step of our methodology is aimed to deduce the *available supply chain processes* within our *logistics network*.

We define an *Available Supply Chain Process* (ASCP) as the succession of all possible partners' activities, available in the *logistics network*, which enable the *logistics network* to answer an *initial logistics need*. This succession of activities starts from the *initial logistics need* and goes recursively from all the first-tier activities able to answer directly the *initial logistics need*, to the last-tier activities within the considered *logistics network*. So, the ASCP includes all the possible partners' activities even if the *effective supply chain process* (ESCP) might not use all of these possibilities. We define the ESCP as the effective process that will be implemented to answer the *initial logistics need*. For example, in the case of a *logistics network* including: a partner who needs a product and three other partners who can supply this same product. The ASCP will link all the last three partners (suppliers in this context) with the first one (buyer in this context). However, for a lot of different possible reasons, the ESCP might only link two suppliers to the buyer. We mentioned that the starting point of all the ASCP deductions is an *initial logistics needs.* We define an *initial logistics need* as a logistics need coming either from outside our *logistics network*, either from partners within our *logistics network* but, in that case, being the final customer of this *initial logistics need*. We introduced this concept in order to make the difference between the logistics needs that our *logistics network* needs to answer with the logistics needs resulting from the processes build in order to answer to the *initial logistics needs*.

2.2.3 Logistics Network and Available Supply Chain Processes Simulation

This third step of our methodology has two main objectives: the first one is to compare the *initial logistics needs* that need to be answered by our *logistics network,* with the ability of our *logistics network* to answer them. The second one is to subject our *logistics network* to stress tests (i.e. simulation of situations of disruption, as for example partner bankrupt, quality issues, natural disaster, etc.) in order to check its robustness in terms of agility and resilience. Montreuil (Montreuil, 2016) did a proposal for a *supply chain disruption framework*, which is a good base for our needs in order to classify the supply chain disruptions.

These simulations will first be done for each ASCP independently (i.e. for each *initial logistics need* independently*)*. It will give us the results on the ability of the *logistics network* to answer each *initial logistics need,* and its ability to withstand disruptions considering only this *initial logistics need*. These simulations will, for example, allow us to identify the *initial logistics needs* that cannot be fulfilled by our *logistics network* even before considering the sharing of the *logistics network* with other *initial logistics needs*. Then, the simulations will be done for all ASCP together (i.e. considering all *initial logistics need* together*)*. It will give us the results on the ability of the *logistics network* to answer all *initial logistics needs* together, and its ability to withstand disruptions considering all these *initial logistics needs* as a whole.

2.2.4 Logistics Network and Available Supply Chain Processes Weaknesses Identification

Now that we have the simulations results from the *logistics network* and the ASCP simulations, the objective of this fourth step of our methodology is to analyze them in order to identify weaknesses within these *logistics network* and ASCP. As we did for the simulation, we will identify weaknesses for the *initial logistics needs* independently and then considering all the *initial logistics needs* together within the *logistics network*. We will introduce a *supply chain performance framework* containing at least the two following supply chain performance categories: *agility* and *resiliency*. It will be designed to fulfill three objectives: the first is to classify the weaknesses within the performance categories. The second is to define the performance metrics and criterions regarding the performance categories. And the third is to automate the weaknesses identification.

2.2.5 Logistics Network and Available Supply Chain Processes Strengthening Actions Recommendations

Using the simulations results and the weaknesses identified, the objective of this fifth step of our methodology is to make recommendations of strengthening actions for the *logistics network* as a whole and for each ASCP independently. These strengthening actions correspond to changes that would enable the improvement of the performances in terms of agility and resilience. As for the weaknesses, recommendation might be classified according to agility and resilience metrics in order to quickly identify the benefits of these recommendations. It makes sense that it includes specific strengthening actions for each ASCP as well as some more global for the overall *logistics network*. Businesses will then be able to consider these recommendations and to take good decisions about their implementation. Finally, implementing a recommendation implies evolutions in the *logistics network* and so the platform will again automatically go through this entire methodology to update the recommendations.

The recommendations deduced from this methodology and proposed to the Logistics Network partners should enable them to be confident taking strategic decisions as the following examples: investments in terms of production capacities, choice of partners for their supply chains, and choice in terms of strategic stocks positions and quantities. This confidence should come as well from the recommendation itself as from the previous results (simulations and weaknesses identification) which should make the recommendations understandable.

3. CONCLUSIONS AND PERSPECTIVES

This methodology we developed respond to our research ambition to provide businesses with a methodology and a platform able to guide them towards the improvement of their *logistics network* and *supply chains performances* in terms of agility and resilience. We will now deepen our research within each of the five steps of our methodology in order to enable its implementation and the development of a prototype as a proof of concept.

Finally, with a constant proactive mindset, we want to point out some perspectives we consider in order to go further in our researches on this project: first, we would like to look forward a generalization of our methodology to take into account any level off granularity and so be able to consider as well the business operational level as the business tactical and strategical levels. Secondly, taking into account the operational level would enable us to design a real-time methodology which could include the hyperconnected concept highlighted by the Physical Internet (Crainic and Montreuil, 2016). Thirdly, we would like to extend this single-viewpoint methodology to a multi-viewpoint methodology and so to bring a single-actor platform to a multi-actor platform. Finally, the apotheosis of our research project might be the generalization of the scope this methodology (including the previous mentioned perspectives), from specific *logistics networks* to a global *logistics web* as described by the Physical Internet (Montreuil et al., 2013).

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