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# A global framework of activities integrating product & supply chain design

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**Abstract:** With the increase of worldwide industrial competition, companies must propose new products in a short lead time in order to answer the requirements of demanding clients. Nevertheless, innovation concerning new products is no longer enough to guarantee strategic market advantages. The product supply chain performance is an important and additional factor to achieve these market advantages. In this context, it is essential for companies to integrate product and supply chain design in order to find proper product solutions considering impacts in supply chain performance. This paper proposes a framework of activities that integrates these two aspects of design phase.

*Keywords:* product and supply chain design, partner's relationship, supply chain performance.

## 1. INTRODUCTION

The success of a new product depends on the success of the product design process, including a good integration and involvement of co-designer suppliers, and on the supply chain design. Indeed, issues regarding suppliers (not just co-designer's suppliers) are very important to launch a new product, since it affects the respect of customer requirements, the time-to-market, the production quality and lead time, product cost, etc. Decisions about supply chain design (supply chain structure and supplier's selection) are crucial to ensure an efficient product design and manufacturing process. This is in terms of operational performance (lead time, cost, etc.) as well as in terms of coordination of these processes, involving relationship management between partners in the supply chain.

As product decisions strongly impact the supply chain structure, product design and supply chain design processes must be coordinated and explicitly considered as concurrent activities. That is to say, supply chain must be designed gradually and connected with the product design progress. This is a complex subject involving different actors: product designers, supply chain managers, buyers. In reality, these companies' departments are still very compartmentalized, at least during the design phase. In most cases, supply chain arises as a "consequence" of product design, without considering neither the decisions about strategies related to this partners' network, or the possibility to change a part of the product in function of the associated supply chain. Product designers have generally little influence on the decisions of supply chain architecture and selection of suppliers. They only influence the decision concerning key suppliers, which become co-designers suppliers. On the other

hand, buyers interact with many suppliers without the possibility to reassess product development in function of the partner network strategy (Zolghadri et al., 2009).

In the literature, issues regarding the integration of product and supply chain design are particularly treated by Supply Chain (SC) Management, Manufacturing Engineering and Purchase communities, and more occasionally by Design community. Nevertheless, they do not treat this subject as a whole. The first two communities usually consider defined product architecture and supply chain performance in terms of lead time and cost. Studies of Purchase community more often concern problems associated to supplier selection; and relationship between SC partners is quite neglected.

In this paper, we adopt a broader vision and propose a framework defining the activities that should be performed in order to coordinate decisions associated to product and SC design. This framework is a first step of a research that intends to propose a reference model of product and SC design decisions which will take account the interaction between designers, buyers and SC managers, vital to construct a consistent product design process based not only on technical product functions but also in SC strategy.

This paper is organised as follow: Section 2 presents a non-exhaustive literature review about product and supply chain design. Two main approaches are identified, analytical and conceptual, and are analysed in this part of the article. Section 3 describes the proposed framework of activities integrating product and supply chain design. Finally, Section 4 concludes the paper, and presents the directions for future works.

## 2. STATE OF ART

Although there have been many articles that address issues concerning product development, supply chain design, suppliers' selection, relationship in the supply chain, etc., there has been very little work that considers all these aspects together during the product development process. Indeed, most works that focus on these issues consider one or two of these aspects. Among these works we can identify two main approaches: analytical approach and conceptual approach.

### *Analytical approach*

A number of articles have been published on the influence of product in supply chain design. Decisions of product platform (Feng et al., 2001; Zhang et al., 2008, Kristiano et al., 2012), component standardization (Gupta and Krishnan, 1999; Baud-Lavigne et al., 2012), mass-customization (Salvador et al., 2004; Huang et al., 2005) and product family (Lamothe et al., 2006; Jiao et al., 2007; Zhang et al., 2008) are associated to supply chain design.

Most of these researches consider a fixed product structure or architecture (in an advanced phase of product development) and propose an optimisation model to design supply chain, usually limited to operational performance concerning minimization of global supply chain cost. The issues associated to supplier selection are rarely broached. When it is taken into account, authors allow for production cost and lead time parameters, without analysing the impact of relationships in the supply chain. Furthermore, the possibility of reassessing the product solution in function of a supply chain performance or logistics parameters is not suggested.

One of the articles that present a broader view of integration product and SC design is (Nepal et al., 2012). The authors proposed a multi-objective optimization model developed to determine the optimal supply chain configuration for each product architecture strategy. It incorporates the compatibility between the supply chain partners into their model in order to ensure the long term viability of the supply chain. The optimization model has two objectives: minimization of total supply chain costs, and maximization of total supply chain compatibility index. They considered three main factors to evaluate compatibility of potential suppliers called structural (cultural alignment, communication and information sharing, and coordination and cooperation); managerial (managerial trust and commitment, compatibility in strategic goals, conflict management techniques); and financial (profit margin, return on investment, bond rating). If this study integrates three aspects of product and SC design (evaluation of partners, product architecture and supply chain operation performance), it does not take explicitly into account the impact of relationship between partners, and which strategy to be adopted to select partners in function of this relationship and the business strategy of the company. Also, the possibility of reassess the product solution in function of a supply chain performance or logistics parameters is not suggested.

### *Conceptual approach*

To better understand the influences and interdependencies between product design and SC design, some authors have proposed frameworks, and conceptual and reference models. With this approach the concept of Design Chain emerges and encompasses all participants throughout the product development process, from concept, detail engineering, process engineering, prototype manufacturing to post-launch activities (Twigg, 1998; Sun et al., 2013). In this context, the proposed models and frameworks present, with different level of details, the process, the elements of these process and their interconnections to better handle product development considering suppliers involvement.

Sun et al. (2013) identified the existing design chain management reference models and attested that among these models, DCOR (Supply Chain Council, 2004) is the most recommended one. DCOR identifies five main processes (Plan, Research, Design, Integrate and Amend) that are decomposed in subprocess in function of three different levels of product innovation. In DCOR, business process, metrics, best practice and technology features are linked to support communication among design chain actors (Juan et al. 2009). However, this model does not specify very clearly the activities associated to supply chain design neither when the different types of suppliers (co-designers, manufacturer, standard suppliers) should be integrated into the product development process, since supply chain design should progress at the same time when product is developed.

Zolghadri et al. (2009) proposed a framework of Co-Evolution of Product design and Supply Chain (CEPS). The authors correlated the different phases of product development process with the different phases of supply chain design. Also, they defined four types of suppliers (risk sharing partners, design partners, manufacturer partners and standard partners) and identified in which phase they must to be involved during the product development process.

Although the important contributions of these models to better understanding interdependencies between product and SC design processes, they need to be more developed to increase the level of integration of these two processes. Thus, it is necessary to better identify how the decisions about product and supply chain design are connected, and the activities to be performed in order to improve the coordination and the consistence of product and SC design process.

Considering this analyse, in the next section we will propose a global framework of the activities necessary to better coordinate the decision of these process. We have adopted a conceptual approach, since we think that before proposing analytical tools, we need to better understand and treat the issues previously mentioned. In our point of view, conceptual approach is more appropriated to reach this objective.

## 3. GLOBAL FRAMEWORK OF ACTIVITIES INTEGRATING PRODUCT AND SUPPLY CHAIN DESIGN

The definition of the product, which evolves during the product development process, drives the SC design process.

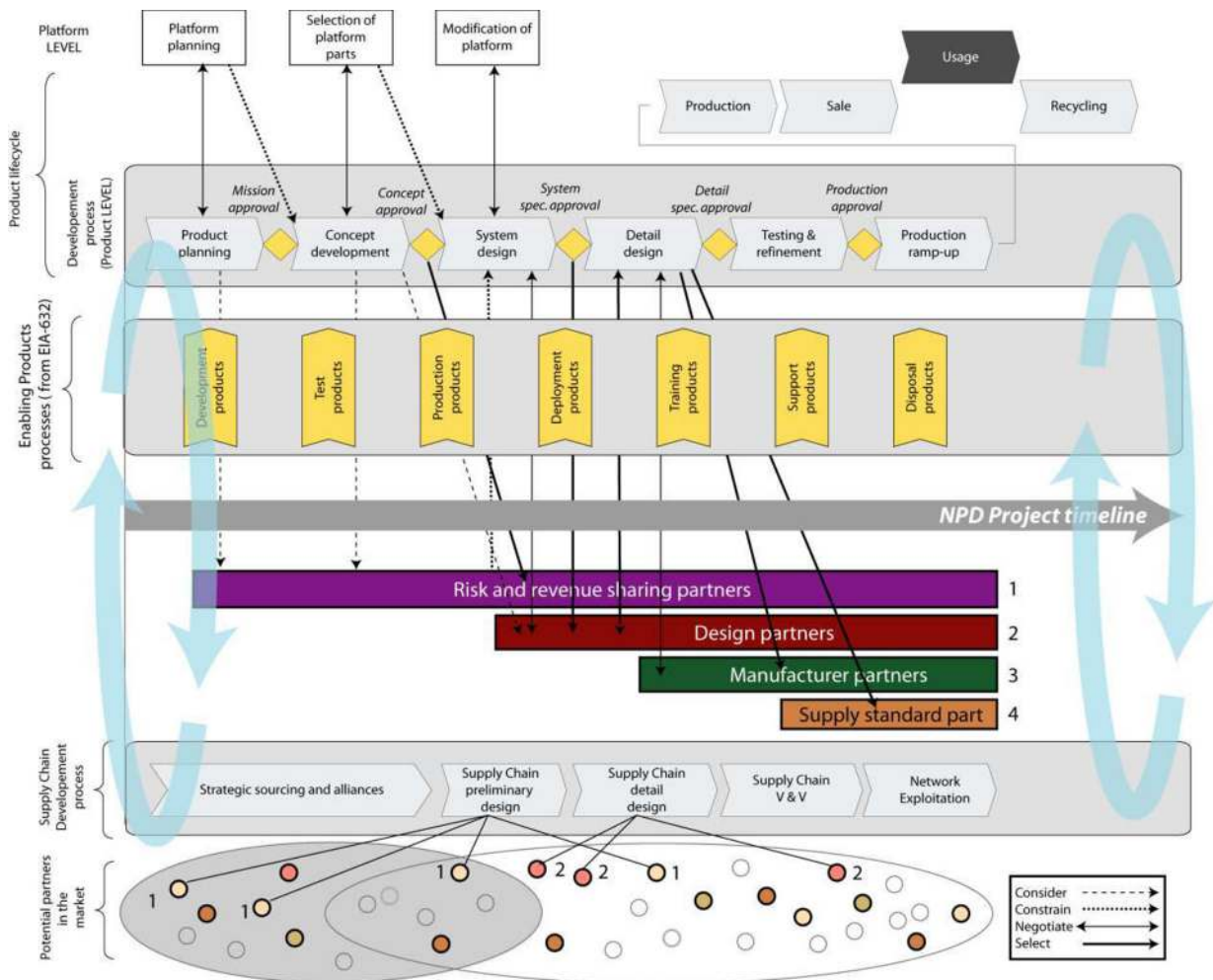


Figure 2. General framework of co-evolution of product/partners' network (Zolghadri et al. 2009)

However, the decisions about this partner network will impact all phases of the product lifecycle. Then SC solutions should be analysed and evaluated during the product development, and the possibility to change part of the product in function of the supply chain performance should be also considered.

The framework presented in this section aims to give a better understanding about the way to integrate supply chain design in the product development process, considering the operational performance and relationship management of this partner network. Also, the possibility of re-assess product specification is integrated in the framework. The framework should help decision makers assess product and supply chain solutions together.

### 3.1 Scope

As said in the introduction section, the framework proposed in this article is a first step of a study that intends to suggest a reference model of product and SC design decisions. Our research is based on the framework of CEPS (Figure 1), which provides the clues to analyze the mutual relations between product and SC. In particular for the framework proposed in this paper, we have taken into account the three

aspects of partners' network considered by CEPS: the structure of the network, the dependencies from demand-supply, and management of the network including maintaining relationship. Based on it, we propose a global view of the activities to be realized to integrate product and SC design, identifying the interactions between designers, buyers and SC managers. These actors are represented by the decision center of their associated company's department and take decisions or execute activities.

In the current stage of our work, the specificities of the different phases of the product development process (concept design, detail design, etc.) are not considered.

### 3.2 Proposed framework

Based on product requirements, designers *identify product functions* (Figure 2) through applying methods like FBS (Function – Behaviour – Structure) (Gero, 2002) and FAST (Functional Analysis Systems Technique (Bytheway, 2007).

Considering the product function specification that emerges from the first activity, *function criticality* is *calculated* through experts' evaluation and applying assessment methods. In this way the added value of the product part associated to this function can be deducted.

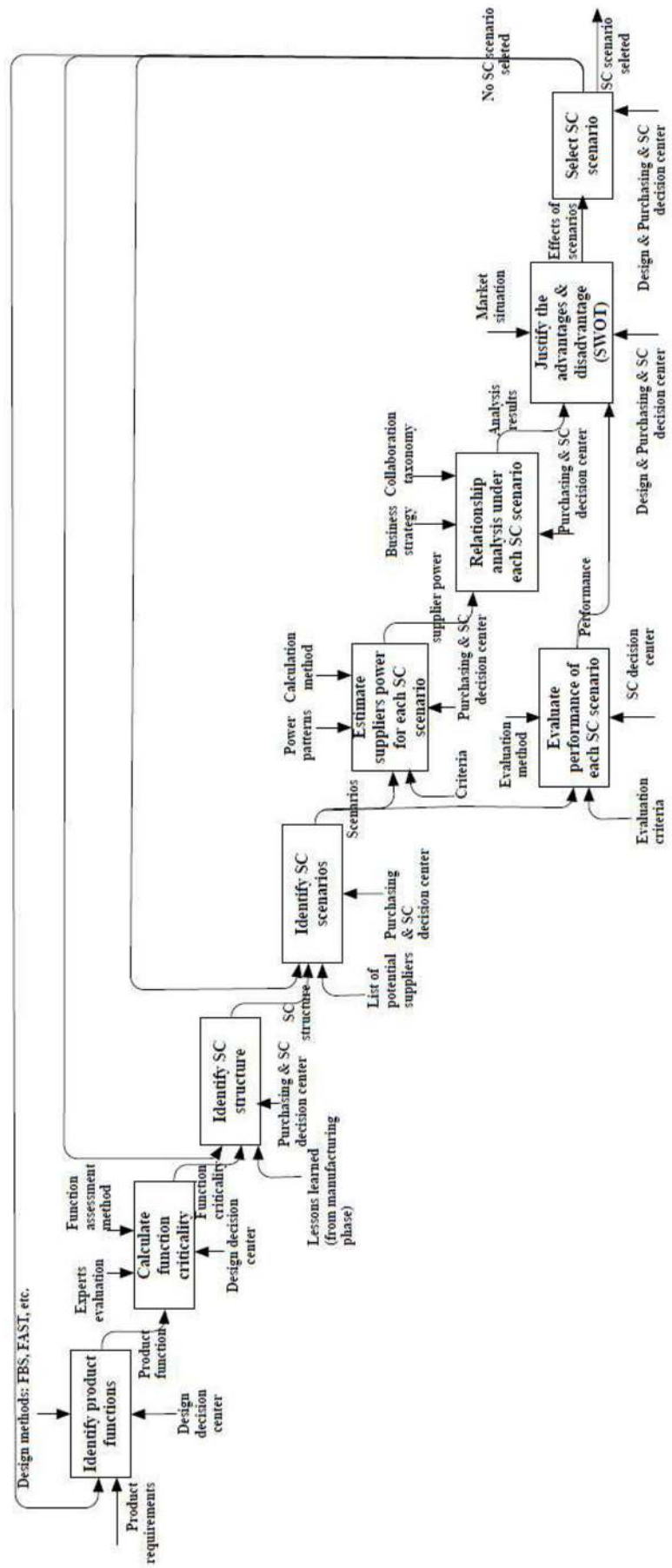


Figure 2. Framework of activities integrating product and supply chain design

This evaluation is important to define relevant SC structures (*Identify SC structure* in Figure 2). It is a first parameter to be taken into account when a company decides to make or buy a part of the product, and so it will directly impact the SC structure. Lessons learned from the manufacturing phase should also be considered in this activity. For example, a company specialized in surface treatment in the south west of France is involved in the aeronautical SC. This company performs an activity quite rare in the region and it has become a constraint to achieve a good efficiency of this SC. However, the “product function” associated to this activity will certainly not be evaluated as critical during the previous activity (*Calculate function criticality*). This is the reason why is very important to take account lessons learned from the manufacturing phase about SC partners in this activity of the framework. It can influence the choice of supply chain structures that will be considered in the SC design process.

After defining SC structures (the most relevant), buyers and SC managers can *identify supply chain scenarios*. In our research, supply chain scenarios mean the supply chain structure with related suppliers. Indeed, for each defined SC structure, one or more scenarios can be identified associating a supplier for each node of the SC. To do this, a list of potential suppliers must be available, including potential new suppliers.

Thereafter, the *performance of each supply chain scenario* can be evaluated. Applying an evaluation model for SC, each scenario should be assessed in terms of “operational” performance. The evaluation criteria have to be defined on advanced, in terms of global lead time, global cost, etc.

In concurrence of this last activity, buyers and SC managers can *estimate suppliers’ power* and then *analyse the relationship* between partners in the supply chain for each scenario. The suppliers’ estimated power, evaluated according to the defined criteria, will directly influence the relationship between partners in the SC. Indeed, some characteristics of suppliers can generate an imbalance force situation between partners. It can be translated as the ability of one company to influence the decisions and behaviors of others (Ramaseshan 2006; Yeung et al. 2009). So, after estimating the power of suppliers in each SC scenario, it is important to analyse how they can influence the SC. These relationships must be analysed taking into account collaboration taxonomy (for example as proposed in (Kraljic, 1983; Marcotte et al. 2009, Zolghadri et al. 2009)). It indicates, for each “type” of supplier, the risks or the strategies to develop a good relationship within the SC. The business strategy of the company must also be considered in this analysis.

Considering the performance of each supply chain scenario, and the relationship analysis, the strengths, weakness, opportunities and threats (SWOT method) are addressed for each supply chain scenario.

Through this activity, designers, buyers and supply chain managers can *select the supply chain scenario* more appropriated. Indeed, they decide together which product parts will be produced by the company, which product parts

will be made by suppliers, which are the selected suppliers, and the supply chain configuration. The SC solution will be as detailed as the development level of the product.

If no supply chain scenario provides a satisfactory result three possibilities can be considered:

- Identify new supply chain scenarios: it means to select other suppliers for the same supply chain structures;
- Identify new supply chain structures: if the final result is not satisfactory, they can decide test new scenarios defined from a new supply chain structure;
- Re-start the process: it means to reconsider the product function specifications to look for a better solution between product and supply chain design.

It is important to note that in these three cases, it is strongly recommended to analyse the reason why the process does not result in a satisfactory solution. Then the actors can transform this experience to lesson learned.

### 3.3 Discussion

This framework is a process-oriented method to help decision makers design supply chain according to the product functions, supply chain configuration and relationship between partners.

In the currently stage of this research, it represents a global view of this process and needs to be detailed considering different phases of product development process and different level of innovation of the product. Indeed, the supply chain design must evolve together with product design. Thus, different types of suppliers (co-designer, manufacturers, standard suppliers) will not be considered in the same phase of the product development process. Moreover, the level of innovation of the product design process must influence the involvement of suppliers in this process. Developing a completely new product, with a new technology, requires a much stronger involvement of suppliers in this process, than developing a new product which is an evolution of an existing product in the company. So, these two aspects probably impact activities and parameters associated of the proposed framework.

Despite these limitations, we think that this global framework is a first tool to understanding the importance of involvements of different actors, having different views of product and SC, and the interaction between product and SC design processes. The definition of these activities and the elements associated to them should allow a better coordination and consistence between product and SC design activities.

## 6. CONCLUSIONS

After a non exhaustive literature review, we have noted that research works concerning integration of product and supply chain design does not take into account together main factors

that strongly influence the decisions related to this topic: the new product functions, the SC performance and the relation between partners in the SC.

Therefore, we have proposed a global framework integrating product and supply chain design. It identifies the interdependencies between activities that define product architecture, supply chain configuration, supply chain performance and supplier selection. The final decision about supply chain design is taken, by designers, buyers and SC managers, in function of all these aspects. Thus, we think that this framework allows a more consistent product and SC design.

In future work, this framework will be specified taking into account different phases of product development process, different levels of innovation and different types of suppliers. Indeed, in the next step, this framework will be developed based on the framework of CEP (Figure 1) and DCOR, in order to define the specifications previously mentioned. At last, we will validate it through an industrial case study.

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