*Moving Integrated Product Development to Service Clouds in the Global Economy*
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# Addressing Product-Service Manufacturing in Globalised Markets: an Industrial Case Study

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**Abstract.** Product-service (P-S) represents an interesting business trend for manufacturing enterprises to push innovation since it allows increasing the value perceived by the customers and better satisfying their needs over time by adding a wide range of services to a physical product. In this context understanding how to configure the global design and production network in order to realize a P-S solution and properly reconfigure the processes against rapidly changing of P-S requirements is a complex problem area. For this purpose new methods are necessary to deal with the complex, dynamic and transient nature of product-services and create a dynamic global network able to effectively manage the flexible design and production requirements demanded by the increasing business need for rapid P-S change. The research presents an industrial case study focusing on a manufacturing company facing the configuration of its production network in order to provide a new P-S idea and innovate its actual product portfolio. In particular, the study defines a methodology to elicit the P-S network configuration requirements and support the P-S introduction in a traditional manufacturing scenario. By using such a method the company is able to define a solution to plan and configure the required network in case of P-S production and organize the partners and the interactions among them.

**Keywords.** Product-Service, Service Innovation, Product-Service Network Configuration, Design and Production network, Industrial case study.

## Introduction

Product-service design and development is an emerging trend in modern industry that involves more and more manufacturing companies. The product-service concept (P-S) consists mainly in the combination of a physical product and a set of intangible services in order to usually enhance the product features and create an added value by new functionalities. The final scope is realizing new market opportunities and bringing competitive advantages in a specific target market [1].

For these purposes, manufacturing companies usually exploit technical services such as maintenance, user training, retrofitting or product monitoring, which can significantly influence customer satisfaction and system performances. However, in order to create such systems, the single producing company is not enough, and partnerships with other companies are necessary to create the service features as well as the system infrastructure. Indeed, new relationships between different stakeholders

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with diverse and complementary skills and competencies must be created to produce both product and service items and properly manage all the lifecycle stages with the creation of a design and production network [2].

Furthermore, the globalization process of recent years has required enterprises to deal with more and more complex business and production scenarios in order to satisfy all their customer requirements and remain competitive [3]. It means that collaboration across worldwide networks of enterprises as well as design and supply chain becomes an important capability to emerge in these highly competitive markets [4]. However, in order to be competitive, these networks need to understand and overcome the potential incompatibility problems amongst the particular information and manufacturing systems in the network [5,6,7].

In this new perspective, P-S can represent a new opportunity to innovative the traditional business and grasp new market shares. In this context, the main challenge for manufacturing companies is the management of relations and data flows, referring to information, materials and resources, among the different companies involved as well as of the process complexity. Indeed, such process involves several sub-processes (from P-S ideation, design, implementation to operation) that highly differ from the current product-oriented process. As a consequence, new methods and tools are required to support modern companies to achieve the following objectives:

- to guide companies in the transition from product to product-service;
- to support organization of global and multifaceted network;
- to manage the product-service lifecycle properly;
- to define the most suitable business model.

The present research deals with such new scenario and proposes a methodology to support manufacturing companies in business process analysis, network configuration and requirement elicitation in order to create a P-S oriented design and production network. Then, the industrial case study presents how a household appliance producer adopted the proposed method to shift towards services by creating smart appliances and managing smart home services: in order to create such P-S systems, it needs to elicit the process changes and consequently reconfigure its own network properly. The case study in particular described how the network knowledge, from the main company and its strategic partners, is analyzed and modeled, how P-S processes and related data flow are defined, and how a business network configuration is implemented.

## 1. Research background

Creating a P-S system requires merging different items: mainly the core product, which is the physical item traditionally offered on the market and is usually produced by a manufacturing company, a set of intangible services to create further functionality and add value, and a proper infrastructure [8]. Indeed, the P-S delivery and operation imply the involvement of organizations, public bodies, tertiary service providers and customers to create a unique business framework, moving from a vertical supply-chain to an extended collaborative network [9]. Furthermore, both product and service need a strong coordination within the Design and Production Network (DPN) processes with a twofold objective: to reach high product performance, and to realize an efficient P-S development process [10].

### *1.1. Process analysis in the global design and production network*

Business process analysis and modeling is the first step to investigate the actual scenario and clearly identify the bottlenecks. Considering a process as a structured, measured sets of activities designed to produce a specified output for a particular customer or market [11], a business process in particular defines the way used by a certain enterprise to achieve its goals [12]. As a consequence, process analysis and modeling allow defining the main activities to achieve the process tasks, and identifying the enterprise's ability in capturing and sharing process knowledge and transferring it. Furthermore, process mapping allows also eliciting data flows from/to inner or external resources as well as groups. Several techniques for business process modeling have been developed: from static modeling focusing on the flow of information (i.e. UML, Petri- Nets, flowcharting, IDEF0, etc.), to dynamic modeling for process evaluation (i.e. Event-Process Chain) [13]. They are useful for process representation and performance evaluation but they mainly refer to product-oriented processes and provide a high-technical view [14].

From a more business-oriented perspective, Business Process Modeling (BPM) techniques are the most appropriate to analyze the scenario. In particular, Canvas model is based on the Business Model (BM) concept as defined by [15] and is one of the most used in manufacturing. It is based on building blocks and provides a more clear definition of company organization considering both product and services [16]. However, traditionally the models obtained are restricted to a value chain, which comprises only the activities executed within a company, without considering the interfaces to business partners like suppliers, customers or sales channels which business partners can conduct. If internal requirements can be identified according to the Canvas Model, external requirements required a more complex mapping. Recently PESTE (Political, Economic, Social, Technological, and Environmental) analysis supports this area by mapping the framework of the macro-environmental factors used in P-S for strategic management by highlighting the external trends characterizing of a certain network and comparing different scenarios to understand strength and weakness [17]. About BPM, numerous techniques and tools exist, but none of them is complete enough to model a complex P-S scenario and, thus, are used in combination.

### *1.2. Requirement elicitation for P-S development*

By definition requirements define the needs of organizations or networks and describe what a solution must offer in order to satisfy those needs. Requirement Elicitation (RE) is fundamental to fully describe processes and determine the way to find the solution for a specific problem [18]. The realization of complex solutions like P-S that requires the temporary collaboration of different stakeholders affects also RE: the stakeholder environment grows in size as well as in complexity, the factors affecting the business process are bigger and more complex, stakeholders are globally distributed, and finally the expected goals include tangible and intangible items. This makes RE particularly strategic, but collaboration during RE much more difficult [19].

To be successful RE has to start from the analysis of users' needs: they first have to be captured and then translated into more formal system requirements. An overview of the most common RE techniques is proposed by [20]. However, a recent paper highlights that traditional approaches are not suitable for P-S and, in particular, they lack in understanding the tacit users' knowledge and formalizing the user-centered

processes [21]. Thus, P-S implies a transition to a service-based ecosystem and the investigation of market needs to properly define the service-based functions. The former issue can be supported by multi-level analysis, an approach used for RE in industrial surveys, which are usually carried out by questionnaire involving the different stakeholders. The latter can be addressed by the Business Use Case (BUC) analysis, which defines a use-case model and a goal-oriented set of interactions between external actors and the system under consideration [22]. The combination of the two techniques with a deep business process analysis and related modeling allows achieving a comprehensive mapping of the P-S distributed processes within the global extended network and the elicitation of the P-S requirement to configure the network itself.

## 2. Methodology

The research approach is based on the combination of BPM and RE to achieve the above-mentioned objectives as cited in the introduction. Indeed, from a preliminary analysis of the company's business processes within a P-S distributed network, BPM allows modelling the interactions and data flows among the stakeholders involved, and RE allows eliciting the company's requirements for network configuration to create a new P-S solutions. The proposed methodology can be synthesized in 4 main steps:

*Step 1. Business process analysis*: it starts from the P-S lifecycle analysis on the basis of [23, 24], and investigates P-S ideation, product-oriented processes (design, manufacturing, use, end-of-life) and service-oriented processes (design, implementation, operation, dismantling), as well as P-S integration, commercialization and delivery. Such an analysis aims at defining the AS-IS scenario representing the current company ecosystem and its DPN. This activity is carried out by directly interviewing the key personnel of the main company and its value chain. This step guide companies to become aware about their actual processes and the meaning of transition from a product-centred business to a service-centred business.

*Step 2. Process modeling*: it aims at mapping the AS-IS processes defined in the previous step and representing them into a unique model by using logical and graphical tools. It serves to clearly define the main activities and the input/output data flow about materials, resources (energy, water, heat and human) and information. This activity is carried out by experts on the basis of data collected in Step 1. It allows mapping the company's processes and managing the product-service lifecycle properly.

*Step 3. Internal and external factor analysis*: it investigates how the final process model is affected by internal and external factors according to the PESTE approach, which analyses political, economic, social, technological, legal and environmental factors. This activity involves key personnel from the company and its network and uses structured questionnaires to elicit both explicit and tacit knowledge. It supports the definition of the most suitable business model by comparing different alternative models and analyzing the diverse effects.

*Step 4. Requirement elicitation for the DPN configuration for P-S*: it combines the process models obtained in Step 2 with the internal and external factor impact analysed in Step 3 and defines the requirements to create a new P-S process model (TO-BE) to properly organize company resources and configure the network at a global level in order to support the P-S lifecycle. This activity is carried out by focus groups involving company managers and led by experts. It supports companies in the organization of their own global and multifaceted network.

## 3. Industrial case study

### *3.1. Case study definition*

The industrial case study used to validate the proposed method is represented by an Italian company producing household appliances; it actually has a worldwide network with supplier and branches distributed all over the world, and in particular it is interested in innovating its actual business through services. Indeed, it is working on connectivity since several years and it is proposing a set of connected devices (e.g. washing machines, dryers, fridges, ovens) addressing the smart home concept.

However, they are still producing and selling products, so that the real benefits for final users are still hidden. In this context the idea is selling new P-S solutions for the smart home to really innovate their commercial offer and provide tangible benefits for its customers. Indeed, services will be oriented to support final users in their everyday life and within their homes by making the devices' use easier, safer and more comfortable. In particular, the TO-BE scenario consists of a set of connected devices that can exploit Internet to provide customer-oriented services, such as:

- Monitoring the devices parameters to check its operation;
- Informing the users about their status and consumptions;
- Providing messages and alarms to support a correct product use and a better lifestyle;
- Providing personalized advices about product care and maintenance according to the devices' status and the users' habits.

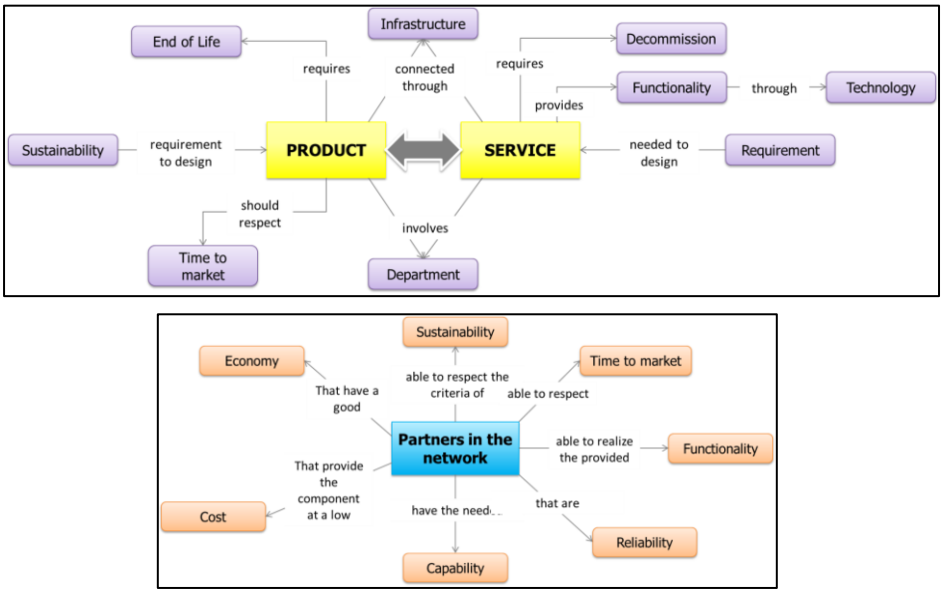


**Figure 1.** Representation of the interview results for business process analysis

In order to realize this scenario, devices must include connectivity components and monitor some specific data as well as the users' habits in product use; they must communicate and exchange data; they must elaborate data for further scopes and extract information about devices' status and users' habits. At the same time, the supporting network has not only to provide devices' components but also services and

the necessary infrastructure. In the following paragraphs the results of the method application to this case study are presented and discussed.

### *3.2. Business process analysis*

The first step of the proposed methodology is the P-S process analysis. The idea is creating the above-mentioned Smart Home P-S scenario. The most affected processes are the P-S Ideation and P-S Design, which in turn directly affect also the following production stages. In fact, the DPN is involved from the early stages of the development process and decisions taken during the first stages determine the following process dynamics. Indeed, starting from these phases, the main actors can be identified in terms of their competences and skills required in each activity involved in the process. As a consequence, in order to properly configure able to develop the above-mentioned P-S solution (i.e. Smart Home devices + Services) the research focused on the early stages of the P-S lifecycle. Figure 1 shows two examples of data collected by interviews (step 1) involving the company management for the analysis of the current partners network and Product-Service relationships.

### *3.3. Process modeling*

Figure 2 and Figure 3 represent respectively the P-S Ideation process and the P-S Design process to realize the desired Smart Home services. Indeed, the P-S infrastructure composed by the products, data collection and elaboration, and service provisioning is almost the same for all services and almost independent from their specific functions. Each process has been modeled through a representation of input, output, resources needed (e.g. tools, detailed knowledge, specific technologies, etc.) and controllers (i.e. the internal department or an external company which is directly involved in such activity). The first activity is market analysis in order to highlight the customers' needs and expectation, the idea definition and the technology definition; finally the cost/benefits analysis allows selecting the most promising P-S solution. This representation is useful to identify not only the activity to develop along the process, but also to recognize all the competences needed to develop the P-S solution, and to highlight especially which one are missing within the company.

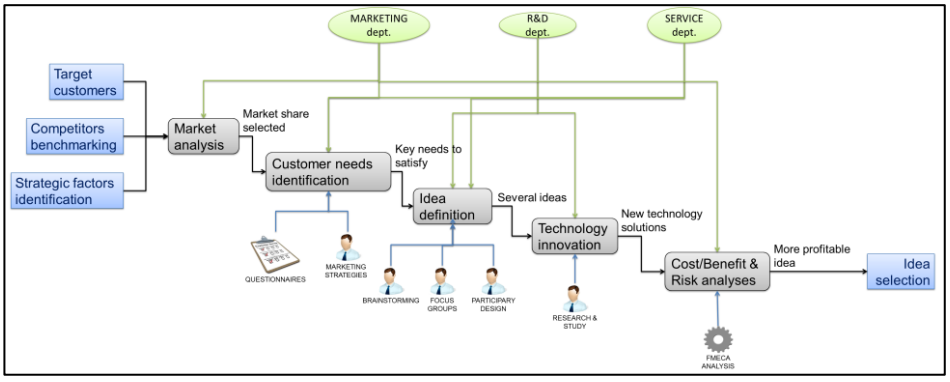


**Figure 2.** P-S Ideation process modeling

### 3.4. Internal and external factors analysis

The aim of this analysis is to identify the main external and internal trends to be considered in the DPN definition and during the P-S development. Indeed, a deep analysis of the company internal factors allows understanding the strengths and weakness of the company itself, but also external factors must be considered as they define limits and constraints that strongly affect intra-company processes and heavily condition the inter-company processes, that are fundamental in P-S development.

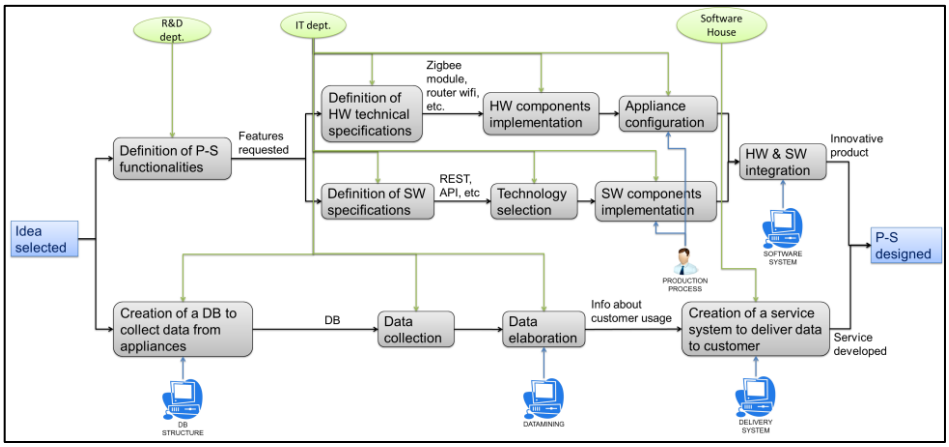


**Figure 3.** P-S Design process modeling

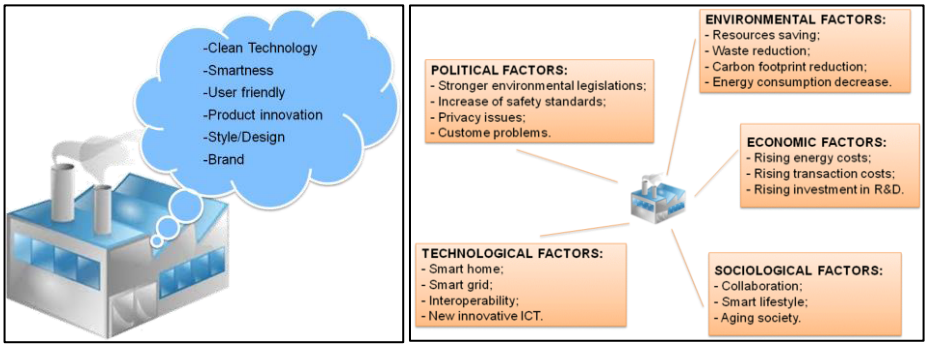


**Figure 4.** Example of the analysis of Internal (on the left) and External factors (on the right)

The internal factors' impact was identified by directly involving company internal people through a detailed questionnaire that investigates several issues: from the company's cost model, to the strategic risks evaluation, the value-network configuration, the suppliers choice factors, the importance of the external factors on the company's business model, etc. The scope is to identify the main factors to be considered in the P-S development process. Such analysis interested each company of the network; the strategic factors emerged during the analysis are also comparatively analyzed considering the main competitors. Next step referred to understand the influence of each factor on the process activities and on the network configuration. The most important factors for the DPN configuration refer to five trends: political, environmental, sociological, technological, and economic, according to the PESTE approach. Also in this case, a, ad-hoc questionnaire is used for the analysis involving

all the partners. Table 1 shows an extract of the questionnaire, which collects the main questions focused on the company's factors analysis. Such an analysis allows evaluating the company's strategic factors and compares them with its competitors. Figure 4 shows an example of the internal and external factors analysis.

**Table 1.** Extract of the questionnaire's questions for external and internal factors analysis

| **Questions about:**<br>**Company's General contents** | **Questions about:**<br>**Strategic factors definition** |
|---|---|
| Definition of: company's products | What factors affect the change in your supply network? |
| Definition of main: suppliers, target customers, services offered, company responsibilities | What factors influence the company's cost model? |
| Description of the design / production process | What factors influence strategic risk in your supply network? |
| P-S Quality | What factors affect the choice of suppliers or any other partners? |
| Definition of the key indicators (focus on: product development process and business evaluation) | How does your information flow look like and how is it modeled? |
| Product Cost impact | How does your material flow look like and how is it modeled? |
| Change management analysis (from only Product to P-S) | Which external environmental factors are influencing your design / production? |
| Management of rules and regulations (at company level) | How do you forecast such factors trends? |
| Current business model evaluation | How do you test your new business models? |
| Method to evaluate new business opportunities | What are the strategic objectives of your company? |
| Methods of assessing and mitigating risks | What are the guiding KPIs on a strategic level? |

### *3.5. Requirement elicitation for the global P-S network*

According to the definition of the P-S knowledge required as well as the identified factors as described in the previous steps, the requirements to configure a Global DPN enabling P-S solution were identified by involving the company managers and two experts from the Academia, who guided the analysis. Table 2 provides an example of the typology of data collected during one of the focus groups. Categories in Table 2 have been defined on the basis of the interview results in Step 1. In particular, the business process analysis allows identifying five main aspects to be considered (i.e. Global Network Management, P-S market, P-S relationships, Business models, and Relations among partners).

The requirements recognized are organized into several categories, which refer to:

- Global Network management, in terms of competences needed to develop the Product-Service;
- Market analysis, in order to identify the most interested customer;
- P-S relationship, in order to identify the main constrains and links between product and service functionalities and components;
- Business Model assessment, in terms not only of key partners, resources, activities, and delivery channels recognition, but also involving the evaluation of such business model defined.

– Relations among partners, modeling the interconnections both in terms of competences and ecosystem network.

Each requirement involves and affects a specific process into the company, from the P-S Ideation process to P-S Delivery process. This phase is very important because allows to identify the main changes that a product-oriented company should do to move to a P-S solution; moreover, the process affected recognition lets to identify the high level of interconnections among the internal and external stakeholders involved in the Global Network.

**Table 2.** Company requirements to define the Global DPN

| Category | Requirements | Affected processes |
|---|---|---|
| 1. Global Network management | • Ability to create cooperation during the ideation and design of a new P-S solution<br>• Identify the main competences and skills needed to design the new P-S solution<br>• Ability to establish and fix relationships with external partners to design and develop the new P-S solution<br>• Identify a tailored workflow to manage the global network | Internal reorganization to share more efficiently the competences needed<br>Design process, not oriented only to the product<br>Decisional process to select and involve new stakeholder (MKTG dept.)<br>Stakeholders management |
| 2. P-S Market | Identify, define and select the key customer segments to model a tailored business model | Business model definition |
| 3. P-S relationships | • Define the constraints and dependencies between product and service<br>• Identify how the dependencies between product and service impact on production process | Product and service co-design<br>Product and service co-evolution |
| 4. Business Models | • Measure the P-S profitability<br>• Measure the company maturity to develop a P-S solution | Business evaluation and company readiness during the P-S Ideation process |
| 5. Relations among partners | • Define how the several partners competences and capabilities are distributed within the ecosystem<br>• Identify the relations among the ecosystem stakeholders | Partners selection during the P-S Design process |

## 4. Conclusions

The present paper proposes a methodology to support manufacturing companies in P-S development by properly configuring their global extended network according to their specific requirements. It proposes to model the P-S processes and analyse the internal and external factors impacting the network organization in order to support the requirements definition and properly configure the Global Design and Production Network. The method has been applied to an industrial use case focusing on "Smart Home Services". The main affected processes have been modelled, and the company internal and external factors have been analysed in details with the focus on the network data flows and interactions among all the actors involved especially in the early P-S development activities. According to the results the main company requirements have been defined: they allow the configuration of the new extended network not only in terms of partners selection, but also in scouting of specific competences and skills to be shared among the network in order to fully support the P-S development and delivery. The method application on an industrial case study

demonstrated its validity and its usefulness to easily represent the process flows) and quickly identify the strategic factors as well as collect the network configuration requirements.

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