How Lean Thinking affects
Product Service Systems Development Process

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Abstract: PSS development involves together, through the servitization phenomenon, both manufacturing and service workers carrying great potential to pursue industrial competitiveness, customer satisfaction and sustainable improvement. The belief is that the development level of PSS design is slowly evolving through a path strongly driven by the evolution of the technology and the progressive involvement of the industry in its application. However companies still need best practices able to improve the PSS development processes performances in a more systematic way. Lean techniques already managed to provide these procedures in a product context allowing the improvement of both product manufacturing and product development processes. The evolution of Lean to an intangible dimension also guided companies' convergence strategy from mass production to mass customization in an efficient and effective way. For this reasons the paper aims to investigate the literature about Lean Thinking evolvement from manufacturing to design phases, as well as from product to service. On this basis, the definition of which are Lean Thinking aspects which could positively affect also PSSs Development will enable the authors to understand which are the more suitable tools to develop Lean PSS and how to provide companies best practices able to improve the PSS development processes performances in a more systematic way. This opens the way to new opportunities and challenges through many further research and industrial projects.

Keywords: Product Service System (PSS), Lean Thinking, Lean Product Service System Development

1. Introduction

In 1968, Fuchs (Fuchs 1968) defined the Service Economy as "one in which more than half of the total labor force is employed by the service sector". Today, the Service Economy is the reality, with more than the 70% of global workers engaged on service tasks (Mont 2002) and manufacturing companies absorbed by the "servitization" revolution (Vandermerwe & Rada 1988). In this, Product Service System (PSS) is generally considered as a special case of servitization, in which a manufacturing company sets its market proposition on extending the traditional functionality of its products by incorporating additional services (Baines et al. 2007) for reaching new market competitive advantages (Porter & Heppelmann 2014). These additional services are often enabled by interconnected and embedded technologies, which permit to trace, track, monitor and control remotely the physical artefact, creating "intelligent, smart and connected" solutions (Porter & Heppelmann 2014). This "PSS smartness" is raising a new set of strategies for customer-focused value creation, long-standing productions (Porter & Heppelmann 2014), and sustainable consumption patterns (Ayres 1998), while the traditional boundaries between manufacturing and services are becoming increasingly fuzzy (Mont 2002). PSSs are nowadays supporting the development of a more sustainable economy (Stahel 1997), switching the emphasis from the "sale of products" to the "sale of use" (Baines et al. 2007), and reshaping the same concept of customer values, from "possession" to "utilization". As for conventional products, the profit generation and the market success of PSSs critically depend on the decisions taken during the initial lifecycle stages, when PSSs are conceptualized, designed, developed and engineered. Notwithstanding the availability of a plethora of tools and methodologies for designing PSSs defined since the '90ies in the context of Service Engineering discipline (Aurich et al. 2006), most of these methods are typically a rearrangement of conventional processes and lack a critical and in-depth evaluation of their real performance in practice (Baines et al. 2007).

2. PSS and Lean Thinking: the evolution pattern

2.1 Product-Service Systems (PSS)

As reported by Baines (Baines et al. 2007), Goedkoop (Goedkoop et al. 1999) gave the first formal definition of a Product Service System (PSS) in 1999, defining its three constitutional elements:

- Product: a tangible commodity manufactured to be sold, capable of fulfilling a user's need;
- Service: an activity done for others with an economic value and often done on a commercial basis;
- System: a collection of elements including their relations.

During the years, many definitions have been introduced in literature (Goedkoop et al. 1999; Centre for Sustainable Design 2002; Mont 2001; Manzini & Vezzoli 2003; Brandstotter et al. 2003; Wong 2004; ELIMA 2005), adding some elements to the Goedkoop's one, but keeping it as the core. The reported authors gave some of the most important citations, on a four-section basis (Definition, Focus, System Components, Objectives). As suggested by Goedkoop (Goedkoop et al. 1999), PSS could consist either on a system/combination (Goedkoop et al. 1999; Mont 2001; Brandstotter et al. 2003; ELIMA 2005), to be intended sometime "pre-designed" (Centre for Sustainable Design 2002), or an "innovation strategy/solution" (Manzini & Vezzoli 2003; Wong 2004). When intended as a combination, PSSs are composed by products and services with an additional support of networks and infrastructures. When instead the concept of strategy/solution prevails, PSS are intended as merely made of products and services. In these definitions, generally PSSs are made to pursue industrial competitiveness, customer satisfaction and also sustainable development (Tukker & Tischner 2006). Different authors (e.g. (Tukker & Tischner 2006), (Mont & Lindhqvist 2003)) have highlighted how this win-win scenario can be realized only by a careful design of the PSS, involving all the significant stakeholders since the early phases of the design stage, as reported in the following paragraph.

2.2 PSS Design

The scientific literature proposes several solutions and methods to design PSSs. The belief is that the development level of PSS design is slowly evolving through a path strongly driven by the evolution of the technology and the progressive involvement of the industry in its application. However companies still need procedures/best practices able to improve the PSS development processes performances in a more systematic way. Hereafter, taking as reference point the state of the art on PSS design methodologies proposed by Vasantha et al. in 2012 (Vasantha et al. 2012), we briefly report the solutions selected in this previous literature review:

- Komoto & Tomiyama (2008) proposed Service CAD, that supports design decision making evaluating the design concepts and suggesting alternatives to improve them, and ISCL (Integrating Service CAD with a life cycle Simulation), which aids quantitative and probabilistic PSS design using life cycle simulation.
- Shimomura et al. (2009), proposed a method (Service CAD) and a SW tool (Service Explorer) for designing service activity and products concurrently and collaboratively during the early phase of product design, representing together human and physical processes in service activity through BPMN and evaluating them with QFD. A simulation tool has been also included enabling service designers to predict service availability (Sakao et al. 2009).
- Aurich et al. (2006), using the UML 2.0, tried to introduce a systematic link between the technical-services design and the corresponding product design process.
- Welp et al. (2008), considering any combination of product and service shares, presented a model-based approach to support an IPS² (Industrial Product Service System) designer generating heterogeneous PSSs concept models in the early phase of development, fostering the functional behavior of PSS artifacts.
- Maussang et al. (2009) proposed a methodology providing technical engineering specifications to complete precisely system requirements. Using SADT (Structured Analysis and Design Technique) representation, they used operational scenarios to fully describe the object-service system. Alonso-Rasgado et al. (2004) considered the different combinations of the two main aspects of Total Care Products, architecture (hardware and service support system) and business (markets, risks, partnerships, business chains, agreements, sales and distribution), trying to choose the most suitable combination of products and services to provide the best solution for all parties involved. From literature, Alonso-Rasgado et al. (2004) showed that the service design process is broadly similar to its equivalent in the hardware field. The proposed approach is the result of the integration of service design, simulation of services, hardware architecture, hardware and service support system costs.
- Morelli (2002) introduced a design process for the development of a support service set in a two dimension space, problem space (often leading to new solutions) and design space.

Among these works, it is possible to find some common practices that are related to the typical methods and tools proposed by Lean Thinking. The next paragraph will identify these main elements, tracing the evolution pattern of Lean from product to service, from manufacturing to design. Then, par. 3 will elaborate a comprehensive vision on how PSS design could be supported by Lean, evaluating at the same time if it could be the best candidate to operate in the development of such systems.

2.3 Lean Thinking

In "The machine that changed the world" in 1990, Womack, Jones and Ross introduced to the big audience the main concept of Lean Thinking (Womack et al. 1990). Most of the book – and of the following literature for almost all the '90ies – focused on the application of the Lean philosophy to manufacturing and operations management, coining the main definition of the Lean Manufacturing concept, "Doing more with less" (Womack et al. 1990). Over the years, Lean Thinking has been deeply defined and coded as a "dynamic, knowledge-driven, and customer-focused process through which all people in a defined enterprise continuously eliminate waste with the goal of creating value" (Murman et al. 2002), in which the costumer – and its satisfaction – should be always put in the first place, while everything not aligned to this should be considered as a waste (*muda* in Japanese). For this, Lean has been primary conceived as the practice (or group of practices) for eliminating and avoiding *muda*, adding more value to products and processes (Soderborg 2008). Today, after almost two decades of discussion, Lean Thinking could be well described by its main five principles (e.g. (Soderborg 2008)):

- "Specify value": correctly specify value from the perspective of the end customer in terms of a specific product with specific capabilities offered at a specific price and time, indeed give the customer what he exactly want.
- "Identify the value stream": identify the entire value stream for each product or product family and remove the wasted steps that don't create value.
- "Make the value flow": make the remaining value creating steps flow continuously to drastically shorten throughput time.
- "Let the customer pull the process": design and provide what the customer wants only when the he wants it.
- "Pursue perfection": strive for perfection by continually removing successive layers of waste as they are uncovered. Pursuing perfection refers to a process of continuous improvement.

2.4 From Lean Manufacturing to Lean Service Operation

The first papers dealing with Lean Service were just some attempts of transferring to service concepts, practices and approaches typically applied in the manufacturing context. In 1969 Skinner stated that concepts of low cost and cut down lead-time, quality and flexibility, derived from manufacturing, could bring service industry to increase the efficiency of their organizations.

Levitt (1973, 1976) was the first author to move some steps towards the 'industrialization of the service sector'. In the 70ies, he recognized the potential of applying Lean Thinking to the service sector but he was oriented to mass production theory.

Pushed by the efficiency-flexibility tradeoff, typical of the mass production theory, Levitt (1973, 1976) brought to the conclusion that service sector could be improved in terms of growth and profitability. Anyway, at the same time, this revealed some gaps. The resulting service offering was very limited because related to rigid technology-driven production systems: e.g. McDonald's case, described by Bowen & Youngdahl in 1998, highlighted that, applying the mass-production-line approach to services, the producer decided what customers wanted standardizing all the their needs. Few years later, Maister (1985) underlined that services are instead supposed to be more flexible and characterized by a high variation due to their major orientation towards the user: human factor should be strategically involved in the process either as employees, who deliver the service, or as customers, who express their needs and expectations.

Subsequently to these first contributions, the birth of Lean Service is attributed to Bowen & Youngdahl in 1998 who followed the stream of the Lean Production of Ohno (1988) and Womack et al. (1990).

For Bowen & Youngdahl (1998) Lean Service has been created to generate process flows in service production and its orientation is towards the improvement of customer satisfaction. In addition, in the lean service the human factor are considered in two different perspectives: the customer who pulls the system and the employee who is completely involved into the process with the use of empowerment and team practices. Lean Service operation has adopted different concepts from Lean Manufacturing such as operation efficiency and flexibility, flow production, pull system-JIT, supply chain focus, customer focus, operators' autonomy (Leite & Ernani 2015).

In the 90ies, Bowen & Youngdahl (1998) reported how few service companies, such as Taco Bell fast foods as well as Southwest Airlines and Shoudice Hospital, adopted lean production-line approaches to their service operation processes: these companies determined what represented value for their customers and then adapted their operation processes to it.

Furthermore, according to Leite & Ernani (2015), Lean Service operation principles still need to be improved: focus on low-cost customer, easy process standardization, co-production and information technology accepted by the customer.

Even if Lean Manufacturing and Lean Service have most principles in common, Lean Service, unlike Lean Manufacturing (where we can remember Ohno (1988), Womack et al. (1990) and Soderborg (2008)), has not a reference model of tools or practices and standards able to manage the different typologies of services yet. A mix of tools and practices is chosen every time in order to best suit the specific needs of a service (Leite & Ernani 2015). Services are indeed subject to a much greater degree of variability of features than industrial production (Arbòs 2002) and this could justify the lack of a unique reference model and approach.

In relation to this, Arbòs (2002) argued that service production seeks, as the industrial production, to implement added value although there are some points differentiating service and industrial operation. Arbòs (2002) focused his attention on the application of Lean Thinking on service operations. He detected the main differences between service and industrial production and introduced some general lean criteria that could be adopted by service companies:

- Linear flow arrangement: in services will be equally convenient, whether there is movement of products or people (case of a personal service),
- Small production batches: in service there is nothing to prevent operation with small production and transfer batches,
- Rapid preparations to carry out processes: the requirement of rapid preparation for small batches is the same,
- Grouping of tasks by workstations (conform to a given takt time): in service a balance also has to be struck based on a variable takt time, applying the same methodology,
- Versatile personnel (able to operate in different

processes and re-assignable depending on takt time): must also be met in services and the methodology for doing so will be the same.
- Quality assurance at each workstation and the proper functioning of production equipment, with suitable preventive maintenance: fully applicable to services.

A recent analysis done by Leite & Ernani (2015), has highlighted the four most commonly used tools in Lean Service Operation:

- value stream mapping (VSM): the application of value stream maps (VSM) is of great relevance to improve the development, preparation and delivery of service processes.
- production balancing (*heijunka*), it focuses on the creation of processes flexibility, developing new ways for better managing suppliers, equipment, processes and teams. In services it could be useful to handle process flows in hospitals (patients), restaurants (meals), financial sector (distribution of credit approval processes) and so on.
- just in time (JIT) and *kanban* allow organizations to deliver services more efficiently (using the minimum amount resources, reducing costs) and effectively (just the right amount, at the right time and place).
- 5S and standardization are adopted to better manage the wastes identification and value focus: these are tools that will ensure process stability in the organizations (especially in those service with expressive movement of people and materials).

As reported by Leite & Ernani (2015), these tools are all connected to the pillars of the Toyota Production System's house, demonstrating a high compatibility between manufacturing of products and services.

Finally, the lean philosophy is not just adopting tools but should be embedded both in managers and employees in order to be continuously inclined to 'do more with less' and improve customer satisfaction through waste removal, resource optimization and establishment of right corporate culture. In order to assist the translation of lean in service sector, leadership commitment and change agent have a strategic role in the organization and creation of awareness of the lean benefits (Asnan et al. 2011).

2.5 Lean Product Development

As already stated, lean principles are nowadays diffused in a large quantity of companies, most of them at manufacturing level. The actual challenge has been to diffuse Lean Thinking all over the company, starting from creative processes, where the success of a manufacturing company is coming from. Only recently more attention has been given to the product development/engineering stage, on the motto that "there is much more opportunity for competitive advantage in product development than anywhere else" (Morgan & Liker 2006). In their recent book, "The Toyota Product Development System", Morgan & Liker (2006) state that in high-competitive market the strategic differentiating factor is the excellence in product development, rather than the manufacturing capability. In the recent years, Lean practices in engineering have emerged as possible solutions for supporting the effectiveness (products quality improvements) and the efficiency (time to market and development costs reductions) of design and development processes.

Lean Principles	Manufacturing	Engineering
Value	Visible at each step, defined goal	Harder to see, emergent goals
Value stream	Parts and material	Information and knowledge
Flow	Iterations are waste	Planned iterations must be efficient
Pull	Driven by takt-time	Driven by needs of enterprise
Perfection	Process repeatable without errors	Process enables enterprise improvement

Table 1. Lean Thinking from Manufacturing to Engineering (McManus et al. 2005)

In this context, a relevant contribution has been done by McManus et al. (2005) who compared Lean Manufacturing and Lean Engineering on the main Lean principles (Table 1), gathering what follows:

- In the development process, "value" is harder to see and the definition of added value is more complex.
- In engineering activities, the "value stream" consists of information and knowledge, not the easy-to-track material flows.
- Due to uncertainties or interdependencies (e.g., between different analytical steps), during design stage branching or iterative flows may be beneficial (this is barely true in production).
- The "pull" to which the process should respond is not just the customer; in product development tasks are usually intermediate steps in an overall enterprise effort to create value.
- "Perfection" is even harder to reach, as simply doing the process very fast and perfectly with minimal resource used is not the final goal; efficient product development process is simply an enabler of better enterprise performance and better products.

Today – after some years of debates – it is possible to identify Lean Product Development as a specific branch of Lean Thinking approach, which is based on three main elements:

- "Waste Identification and Value Focus" (Morgan & Liker 2006): wastes need to be identified and eliminated, and non-value-adding activities kept to the minimum. The related core lean tools used can be the 5Cs (1. clear out, 2. configure, 3. clean and check, 4. conformity and 5. custom and practice), the 7 wastes (1. Defects, 2. Overproduction, 3. Transportation, 4. Waiting, 5. Inventory, 6. Motion, 7. Processing), visual control and standardization of processes.
- "Set-Based Concurrent Engineering" (SBCE) (Ward et al. 1995): in a lean design context more design alternatives are evaluated in parallel step-by-

step, supporting the selection of the best solution along the process, taking care of constrains of the different involved actors and lifecycle phases (e.g. manufacturability, serviceability, environment, user experience etc.).

- "Effective Knowledge Management": as (Grover & Davenport 2001) pointed out, "[knowledge management] is rapidly becoming an integral business function for many organizations as they realize that competitiveness hinges on effective management of intellectual resources". IT collaborative systems (e.g. PDM, PLM, databases, web platforms) and authoring software (e.g. CAD, simulation tools, etc.) are the solutions for archiving and accessing the increasing volume and diversity of information types.

2.6 Lean Service Design

Since the mid-1990s, Lean Production is not only focused on manufacturing management of the company, becoming a general methodology, called Lean Management, applied to various activities as product development, relations with suppliers and customers, distribution (Danese 2011). Indeed Wei (2009) investigated "How can Lean practices be successfully applied to non-manufacturing operations": he detected five distinct attributes of service operation: intangibility, heterogeneity (uniqueness), simultaneity (of production and consumption), perishability (of the service provider's capacity) and customer participation. Based on the main theories which analyze the processes that a good service needs to have (Customer Contact Theory, Variation Reduction and Control Theory, the Unified Service Theory (UST), Lean Service) and which assess the interaction between the service provider and the customer (Service Quality Theory, Service Recovery Theory, Attribution Theory, Service strategy and integration), he proposed "Ten Lean principles of service process design":

1. The baseline, Walk the value stream: walking along the operation processes that form the value stream and then document the stream with visual tools.
2. Identify waste and ask "5 whys?": With all the processes visualized, identify the seven types of wastes and search for remedies to improve the current system.
3. Be proactive via "five S" and "service inventory": Develop a sustainable system to organize the work place so tools and information are available at the time of use.
4. Error-proof the process: Design tools and mechanisms to prevent error from happening or passing downstream.
5. Manage "loop-back": Examining the necessity of looping back and keeping only the essential steps will help streamline the decision processes.
6. Enable 1-piece flow: High setup time or cost is often the root cause of "batch-and-queue" processes. There are several proven tactics for reducing setup time for services that can yield considerable operational improvements.
7. Standardize: Standardized work forms the basis for Kaizen (continuous improvement), however balancing between enforcing standardization and making the system too rigid that stifles creativity.
8. Buffer the bottlenecks: Managing bottlenecks relieve the temptation of adding unnecessary capacity.
9. Segment complexity: Ensure that complexity in design and service delivery process is justified.
10. Promote transparency: Transparency is paramount in aligning internal values with external customer values.

Reminding to the Lean Management definition Womack & Jones (1996) and Bortolotti & Romano (2012) tried to find the right trade-off between process streamlining and automation in order to avoid errors and waste. Tools such as VSM, *Heijunka* boxes and *Kanban* have been used: all is enabled with the commitment of a multifunctional team, including ICT, to better understand the real needs and listen the 'voice' of the customer. This is made easier thanks to process modelling and VSM that allow visual management and waste elimination. Thus, 'lean first then automate' framework (Bortolotti & Romano 2012) allows also testing and continuous improvement. Moving to a more general context, Dombrowski et al. (2014) provided some guidelines for integration of Design for X (DfX) approaches in Lean Design. They started from the idea that product characteristics create product properties and determine the behavior of the product, like reliability, user-friendliness, manufacturability, testability or maintainability. Therefore, they defined:

- product characteristics, under the direct influence of the developer in a design view (in which product is the sum of parts, their properties and their relationships);
- product properties, that cannot be set by the design engineer and which describe the fulfillment of customer and process requirements in a value and a waste view, so products are the sum of all lifecycle processes and of the functions they perform).

The relationship between these two parts is described by qualitative design guidelines given in the DfX approaches. In this context, Design guidelines in Design for Service aim to improve the serviceability (product property) of a product. For this purpose some design guidelines are given, as minimize the number of parts, develop a modular design, avoid separate fasteners, use standard components, avoid sharp edges and corners, provide easy access for locating surfaces, minimize the needs for special tools, etc. However, this approach requires further researches, presenting some limitations (it is qualitative and detects only positive effects) but could be useful for design engineers to take design decision in holistic context.

3 Towards Lean PSS development

PSS design and development is a process that requires a huge effort, also in terms of technical specialization, business organization, data and knowledge management. This is due by the intrinsic complexity of such PSSs and to

the different needs and expectations they are supposed to satisfy in a fast and adaptive way. The majority of the methodologies proposed in literature for PSS design and development "*have a clear heritage in Concurrent Engineering and Lean Product Development methodologies: identification of customer value, early involvement of the customer in the system design, effective communication, information sharing, and continuous improvement*" (Baines et al. 2007). The next step to do is to understand in which way and how much this existing approach could be able to improve the development level of PSSs.
Assessing how Lean Product Development elements are mentioned and used by the PSS design methods, the most upsetting result is that all the methods involve Lean Thinking approaches even if they don't refer to them directly. In particular, Set-Based Concurrent Engineering (SBCE) appears to be the most appropriate approach to manage the PSS design process, even if almost none of the papers quote SBCE directly! In its essence, SBCE process should support the identification and the definition of the most appropriate integration of components and services, aiming at the resolution of the possible design trade-off along the whole development process, stage-by-stage. Some authors have addressed the relevance of an effective knowledge management, generally proposing the adoption of IT solutions, even if just one contribution (Garetti et al. 2012) proposes the adoption of a collaborative design platform typically used in engineering processes, while other authors suggest the adoption of simulation IT-based tool specifically defined for Service Engineering.
It is also possible to see how PSS design methods are focused to the waste elimination and value identification. All the considered papers propose the application of methods and tools for eliminating *muda*, like the 5C approach (Clear out, Configure, Clean and Check, Conformity, Custom and Practice) or similar. At the same time, most of the works suggest and support standardization practices in the PSS design process. Generally, they propose to adopt common process (e.g. BPMN (Shimomura et al. 2009; Sakao et al. 2009), UML 2.0 (Aurich et al. 2006), SADT (Maussang et al. 2009), etc.) as well as standard models (e.g. QFD (Shimomura et al. 2009; Sakao et al. 2009)) and templates (e.g. View model (Shimomura et al. 2009), Service Requirement Tree (Pezzotta et al. 2014)). These standardization practices are normally considered as the basis for promoting continuous improvement consciousness. A part what it is mentioned, it is interesting to notice also what it missing in the analyzed contributions, in a Lean Product Development perspective:

- At first, none of the contributions has clearly and systematically identified which are the typical *muda* to be considered in a PSS design process, while also the definition of what is a value-added activity is often vague.
- Second, none of the contributions is quoting SBCE, even if all of them are proposing/suggesting a design process structured according to the SBCE archetype (Morgan & Liker 2006).
- Third, practically no contribution is investigating/mentioning the role which could be played by computer-aided design and engineering tools already existing in the normal engineering practice.
- Fourth, the application of the proposed PSS design methodologies is most of the time at a prototype/piloting stage and no detailed guidelines on how lean-inspired mechanisms should be implemented are given.

4 Conclusions and further researches

The above open issues support a first remark: in order to improve PSS design with the support of the Lean, knowledge sharing among different academics communities (e.g. experts in PSS design, lean, computer aided engineering, etc.) is needed. Then, industrial practitioners should be as well involved in this debate, for considering the real state of practice of design processes. In an industrial context rigorous definition and representation of technologies are important: issues related to service design are increasingly being recognized by designers and managers as relevant, even though the knowledge on how to develop a PSS and who should design it is still marginal (Luczak et al. 2007). Literature shows that most of the existing PSS methodologies have a clear heritage in Concurrent Engineering and Lean Thinking, even if there is still the need of a comprehensive approach, which groups the elements and provides powerful guidelines. Being often PSS design more or less implicitly structured according to some core Lean pillars, we believe that Lean Thinking could be the best candidate to operate in the PSS design systemization.
Despite of the great involvement of the academic context in PSS design, the scientific contributions as well as the industrial experiences considering also the potential role Lean Product Development methodologies and tools are still few. This means that there is room for performing further studies and identify which could be the challenges to be addressed.
According to the performed analysis, it is useful to detect which tools already adopted in the service framework should be also functional to solve the previously reported issues in PSS development process. Tools such as VSM, *Heijunka* boxes and *Kanban*, with the commitment of a multifunctional team, including ICT, to better understand the real needs and listen the 'voice' of the customer, should be strategic also in the PSS development context. Indeed, especially process modelling and VSM allow visual management and waste elimination.
First of all the creation of a well-structured glossary on the main notions and terms related to PSS, including a well understood definition of PSS, PSS lifecycle management, PSS development and Lean PSS Development. Only basing on a strong taxonomy of these concepts will be possible to achieve the main outcome of this research, a Lean PSS methodology aimed at systematizing the early phase of PSS development in an effective and efficient way.
It is notable and useful to know that a plethora of tools and approaches both for product and service design have been developed. Furthermore during the years there have been many attempts to adapt some of them from a tangible to an intangible dimension and viceversa. Subsequently lean

tools have been adopted both for products and services but mainly the service context still reveals some significant gaps. In this scenario Service Engineering plays a strategic role, supporting Service Systems and PSS development in a systematic and methodological way (Bullinger et al. 2003), based on the assumption that service can be developed in the same way as physical products (Torney et al. 2009). Thus the resulting framework could be based on:

- attuning models and methods created on purpose both in a product and in a service development context,
- a further improvement and implementation of the existing PSS methodologies, that however are still at a prototyping status,
- a combination of the two previous solutions.

Hence the methodology will not probably be developed with the intent of drastically change the way PSS development are actually performed, but with the aim to understand which are the more suitable tools to develop Lean PSS and how to combine them. The second purpose is to provide companies procedures/best practices able to improve the PSS development processes performances in a more systematic way. This opens the way to new opportunities and challenges through many further research and industrial projects.

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