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Early-stage assessment of PSS concepts: a case study in automation industry

Fabiana Pirola^{a,*}, Giuditta Pezzotta^a, Alice Rondini^a

^a University of Bergamo, Department of Management, Information and Production Engineering, Viale Marconi, 5, Dalmine (BG), 24044, Italy

* Corresponding author. Tel.: +39 035 2052005. E-mail address: fabiana.pirola@unibg.it

Abstract

Manufacturing companies are moving toward new business models based on Product-Service System (PSS). Academic and scientific literature reveal that there is a lack of suitable methods, tools and methodologies to support early PSS design activities and, in particular, early PSS concepts assessment. This paper focuses on identification and selection of PSS concepts in an Italian product-oriented company working in the automation sector willing to move toward the provision of product-service solutions. The Engineering Value Assessment (EVA) method has been selected and implemented to assess and select PSS concepts able, from one side, to fulfill customer needs and, from the other side, to ensure company profitability and alignment with its long-term strategy.

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1. Introduction

In recent year, manufacturing companies are moving toward new business models based on a bundle of products and services, the so-called Product-Service System (PSS) [1]. Even if several successful examples show how this new business model could generate higher and more stable revenues, [2] demonstrated that the servitization paradox is still actual and there are several examples of firms that have servitized but that are unsuccessful. The main reason behind this can be found in the lack of suitable methods, tools and methodologies to support early PSS design activities, integrating product and service concept since the beginning and evaluating early design concepts based on both customer and company needs [3,4,5].

This paper focuses on the introduction of PSS offering in a typical Italian product-oriented company working in the

automation sector willing to move toward the provision of product-service solutions. The paper presents how to support the company along its servitization process with a focus on the identification and selection of PSS concepts able, from one side, to fulfill customer needs and, from the other side, to ensure company profitability and alignment with its long-term strategy.

To this purpose, the first steps of the SEEM methodology [6] has been adopted. However, the paper focuses on the PSS concept assessment as an important phase to guarantee an effective PSS introduction in the company portfolio. To this end, the Engineering Value Assessment (EVA) method proposed by [7] has been selected and implemented to support the company servitization process. It consists of a 2-step multi-criteria decision-making approach to assess, from both customer and provider points of view, PSS concepts in the early

design phase.

The paper is structured as follows: section 2 provides a brief literature review on PSS design assessment, section 3 describes the EVA method for early-stage assessment of PSS concepts. This method has then been implemented in an Italian company as described in section 4. Section 5 concludes the paper with a discussion.

2. Literature analysis: value assessment of early-stage PSS concepts

Among the early PSS design activities, the ideation and early selection of PSS concepts that would be implemented into the company offer are critical phases. In these phases, engineers must identify PSSs that ensure a good ‘fit’ with the firm’s existing unique competencies, experience and reputation [8]. Many authors recognize the early stage development phase as a critical phase for the subsequent development [9,10,11]. Despite that, a literature analysis on the available techniques for PSS assessment reveals that the majority of the existing approaches are data intensive and are hardly applicable in situations where information related to costs, markets, prices and processes are unstable, i.e. early-stage assessment [12,13]. Some examples are the methods proposed by [14,15]: they are not suitable for early assessment as they require plenty of information about concepts that are not available in the early stage of engineering. Only a small group of the identified works deals specifically with early PSS design concept assessment. In any case, all these approaches for the evaluation of PSSs do not focus on the overall PSS concepts but on different sub-objectives, such as sustainability [9,16] or customer satisfaction [17]. Most of the proposed approaches assess the PSS solutions from the viewpoint of customers, evaluating the solutions only considering how they fit with customer requirements. The method which supports explicitly the assessment of the solutions considering the provider performance associated with the solution is the “ProVa method” [18].

As underlined by [7], the methods retrieved from literature deal either with the customer (CV) or with provider (PV) perspectives, failing in integrating the two and in guiding the identification of a proper trade-off between the customer requirements and the profitability and convenience from the viewpoint of the provider.

Hence, for the knowledge of the authors, only the Engineering Value Assessment (EVA) method proposed by [7] proposes a quantitative assessment of PSSs concepts in an early-stage of engineering taking into account both the provider and customer perspectives. For these reasons this method, briefly described in the following section, has been selected to support the abovementioned Italian company in the assessment and selection of new PSS concepts.

The purpose of the assessment is twofold: on the one hand to define the best PSS portfolio since the early design phase, on the other hand to identify which are the elements of strength and weakness that characterize such a portfolio and on which it is necessary to work to support the company to move from a pure product-oriented to a PSS-oriented strategy.

3. The EVA method

As above-mentioned, the EVA method aims to assess PSS concepts finding a trade-off between customer and provider values. It can be used in accordance with other engineering approaches such as the Service Engineering Methodology - SEEM [6] or independently to classify and select the PSS concepts to be further detailed and developed.

The EVA method is composed of two different steps and in each step two assessments are carried out: one from the customer viewpoint and one from provider viewpoint. The first step uses as input the list of PSS solutions for a high-level evaluation of the concepts. The output of this phase is a selection of concepts with high customer and provider values. It could also entail a refinement and or a combination of the concepts into new PSS concepts with high customer value and provider value. Then, these selected PSS concepts are assessed in more detail in the second step to come out with the final selection of concepts to be designed and implemented into the company. Two exhaustive sets of evaluation criteria (one for the provider and one for the customer point of view) are also proposed at each step. To perform the assessment, the EVA leverage on a mixture of existing methods either already used in PSS engineering or belonging to other fields. In particular, step 1 uses the Weighted Pugh Matrix [19] while step 2 uses TOPSIS method [20]. At the end of each step, EVA foresees the adoption of the Importance-Performance Analysis (IPA) matrix [21] to combine the evaluation scores of the two actors involved.

3.1. Step 1: Pugh method with high-level value criteria

The main purpose of Step 1 is a high-level assessment of PSS concepts and the identification of opportunities for improvement, recombination and refinement of them. To this purpose, Pugh enables the comparison of PSS concepts with respect to a PSS already offered by the company (called baseline) based a proposed set of value categories. A score of “0” is assigned to the baseline in all the value categories. All concepts under evaluation are then assigned a (+), (-) or (0) if they are, respectively, better, worse or equal to the baseline for each value category. In addition, weights are given to each value categories in order to stress their relevance for the company.

3.2. Step 2: TOPSIS method with more detailed value criteria

The second step aims to a more detailed evaluation of the PSS concepts selected in step 1 considering a broader and more complete number of criteria. To this purpose, for each value category used in step 1, a number of criteria are identified.

This second step is based on the TOPSIS technique. It is based on a mathematical algorithm, and it measures the shortest distance from a positive ideal solution and the farthest distance from a negative-ideal solution. As for the previous step, this assessment is repeated twice, one from customer and one from provider perspective. Each one is carried out following the specific set of criteria.

For more details regarding the method, the steps and the specific value categories and value criteria, refer to [7].

4. Case study

The EVA method has been selected to support an Italian company in the selection of new PSS solutions. The company is one of the main Italian producers of automation systems for residential use, namely automation systems, and the related accessories (e.g. remote controls, photocells, flagship light), for gates and garages. The company has always been strongly product-oriented and all the innovation introduced so far is related to product. They only offer a support service to installers and final users through an external call center. Despite that, leveraging on the new technologies and the increased connectivity available, they are willing to move towards the provision of Product-Service Systems in order to increase their revenue and customer loyalty.

The company value chain is quite complex and three main customer channels can be identified:

- *Wholesalers of electrical equipment*: this is the most important channel in terms of sales volumes since it accounts for about 60% of the company's turnover. The company sells its products to wholesalers, who, in turn, sell to "small" installers who sell and install the product to the final users. The installers in this channel are mainly generic electricians who carry out about 5-6 interventions of this type per year.
- *Professional channel*: it accounts for 30% of the company turnover and it addresses professional installers specialized in automation, who carry out a higher number of interventions per year.
- *OEM channel*: it guarantees 10% of the turnover and is characterized by the direct sale to manufacturers of civil and industrial doors and gates.

The main criticalities of the market that hampers the introduction of services are the following: i) it is difficult to reach the final user since the value chain is quite long and there are several intermediaries, ii) the product is considered a commodity from final users and, then, the focus is more on the price rather than on its features, and iii) the generic installers are not prone to innovation, leading to failure when new technologies and services are proposed to them.

Given the characteristics of the market, the focus of the analysis has been the wholesaler's channel and the main customer taken into consideration is the installer, namely the generic electricians who sell and install the product into the customer house. Thus, the aim is to identify the services that can be offered to the installers along with the product, in order to increase the market share and the related revenues.

The case study has been carried out following the steps suggested by the SEEM (i.e. customer needs analysis, process prototyping, process validation and offering identification and analysis). Thus, the starting point has been the identification of customer (i.e., installer) needs. This has been done through a brainstorming session and the adoption on the PSCT [22] with the main company decision makers, namely: R&D manager, division manager, sales manager, product marketing managers,

product manager, training and service manager, business area manager. These people have direct contact with customers or have a high knowledge of the products and the technologies available to improve them. The brainstorming session lasted about 4 hours and the following concepts have been devised:

1. *Training software/hardware*: to ensure quick and legally compliant installation. It entails documentation and courses that allow respecting the type of product in terms of the law (with study of the impact curves).
2. *Installation with augmented reality*: use of augmented reality through smartphone to support installation.
3. *Visual manuals*: provision of visual manuals with drawings explaining the installation phases; these could be provided through app in order to reduce printing costs and make constant updates.
4. *Youtube tutorial*: a QR code placed on the product linked to youtube content to view videos. This solution can be seen as an intermediate between manuals and augmented reality.
5. *Customized kit configurator*: possibility to configure the product and the installation kit via app, reducing the complexity of the installation and the number of calls due to installation problems. In addition, the configurator would allow the installer to have a "shopping list" based on the solution chosen to buy everything from the wholesaler.
6. *App for configuration and quotation*: product configurator offered through app to customize the product and get a quotation.
7. *Installers list*: the installer can become a "recommended installer" by the company and be included in a list freely accessible by end users.
8. *Accreditation programs*: training and events to get known and trained in products and then be included in the "recommended installer" list.
9. *Automatic certificate*: check list that allows the installers to automatically generate a certificate assuring that the installation complies with the local regulation.
10. *Safety procedures for installers*: courses and events that allow developing knowledge in this field.
11. *FAQ/troubleshooting*: dedicated area in the website/app where the installer can find answers to frequently asked questions.
12. *Maintenance supported by augmented reality*: the maintenance of the automation system is performed through the support of augmented reality which ensures a more effective and efficient intervention.
13. *Free assistance in pre-series*: offer for the pre-series product a period of free service that would allow also the company to improve the knowledge about the behavior of the new product and its main problems.
14. *Preventive maintenance programs*: possibility of creating contracts between the installer and the end user for scheduled maintenance.

4.1. First step concepts evaluation through EVA methods

The fourteen concepts identified by the company have been assessed using the EVA method. To this purpose two single interviews (one per each step) with the main decision makers has been carried out.

Each interview has been assisted by one of the authors acting as a facilitator. In the first step interviews, the facilitator provided a general description of the overall method, its steps and the list of categories for the high-level assessment in order to create a shared understanding among the participants. The first steps value categories proposed by the EVA method and adopted in the case are reported in table 1 (provider - target company) and table 2 (customer – installer) along with their description and classification as cost or benefit. Then, the team was asked to rank weights (from 1 to10) for each category and assess each concept taking as reference service the customer support through call center. This first assessment has been done evaluating both customer perspective and company perspective. As a result, two tables for each interviewee has been obtained, the first evaluating the importance of each category and the impact of the identified concepts from customer (installer) point of view and the latter from the target company point of view.

Table 1. First step value categories for the target company

Type	Category	Definition
Benefit	Strategy	Corporate image and brand strategy, revenue stabilization and alignment with existing corporate strategy
	Capability creation and retention	Strengthening of human resources skills, traceability of information, sharing of data and knowledge with the customer, time to market, reuse of projects and past knowledge
	Asset and resource management	Transfer, efficiency, flexibility and optimal use of assets and resources (asset/employee)
	Market	Acquisition of new customers/markets, improvement of the competitive position and the loyalty of current customers
	Environment	Reduction of the consumption of natural resources and recycle/reuse of parts
	Value chain	Generation/exploitation of alliances in the value chain, strategic positioning in the value chain and efficiency of the supply network
	Innovation	Innovation level of the company, considering both service and product
	Cost	Design costs
Implementation costs		Solution implementation costs and resource training
Operating costs		Product, service and infrastructure supply costs
Disposal costs		Product and material recycling costs and disposal costs
Costs to comply with regulations		Costs to comply with law regulations
	Network costs	Coordination costs with other actors and information sharing costs

Table 2. First step value categories for the customer

Type	Category	Definition
Benefit	Capability creation and retention	Strengthening of human resources skills, traceability of information, sharing of data and knowledge with the provider, improvement of infrastructures
	Asset and resource management	Asset/resource safety, improved asset delivery, improved usability, efficiency and flexibility of asset/resources
	Business opportunity	Opportunities to generate new revenue, partnerships, new markets
	Environment	Reduction of environmental impact by extending the useful life of the product and reduction in the consumption of natural resources
	Intangibles	Product aesthetics, product

	Value in use	installation/ maintenance experience and empathy with the provider Product reliability, safety, flexibility and ease of installation, customizable solution
Cost	Acquisition costs	Cost of purchase of the service, cost of the product, cost of the solution
	Operating costs	Cost of delivery of the product, service and operating cost of the infrastructure
	Network costs	Coordination costs with other actors and information sharing costs
	Costs to comply with regulations	Costs to comply with law regulations

The implementation of the first step of the method (Pugh method) as described in section 3, has led to the result represented in Fig.1.

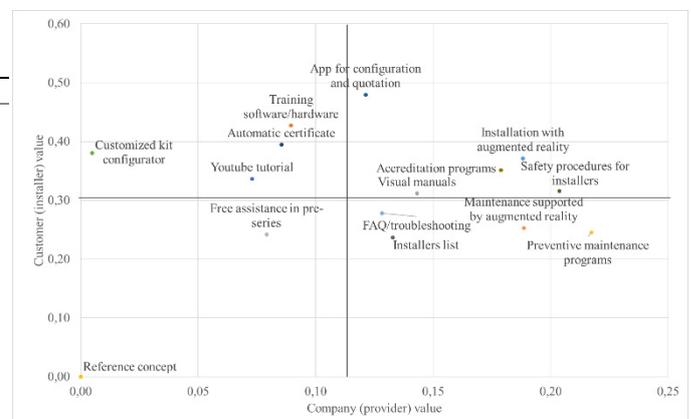


Figure 1. EVA step 1 results

The graph shows the assessment of all the concepts considering their impact on the provider (the target company) and the customer (installer) with respect to the reference concept (i.e. customer support through call center). In accordance with company point of view and considering the scores obtained by the different concepts, the graph area has been divided into 4 areas, as suggested by the IPA matrix. The concepts in the right upper quadrant are those ones with higher value for both actors. They should be selected to be further assessed through the EVA second step. This first analysis showed that the most interesting services are: *installation with augmented reality*, *accreditation programs*, *safety procedures for installers*, *visual manuals* and *app for configuration and quotation*. In addition, *maintenance with augmented reality*, *installers list* and *preventive maintenance programs* services resulted interesting mainly from providers point of view, while *training software/ hardware* resulted interesting mainly for the installer.

Besides the quantitative analysis of the results, a qualitative analysis has been carried out, highlighting strengths and weaknesses of each concept from both perspectives.

As a result of the quantitative and qualitative analyses, the following six concepts have been identified for the second step of the EVA method:

- installation with augmented reality
- preventive maintenance programs
- visual manuals

- app for configuration and quotation
- installers list
- accreditation programs

This first step allowed to cream off the most valuable concepts from the set of concepts came out from a creative identification process. In this phase further concept refinement or merging of more concepts are possible in order to better delineate the PSS portfolio. The second step aims to select the PSS(s) that will be then detailed designed by the company following the SEEM methodology, both in terms of service, product (if it is needed), network and infrastructure.

4.2. Second step concepts evaluation through EVA methods

For the second step of the EVA method, a further interview has been carried out with the same people involved in the previous phase. For each first step category, more detailed criteria have been defined starting from the ones suggested by [7] and adapted to the case under analysis. The criteria lists are reported in table 3 and 4.

Table 3. Second step value criteria for the target company

BENEFITS	COSTS
Strategy Corporate image and brand strategy Revenue stabilization Alignment with existing corporate strategy	Design costs Service design cost Product design cost Infrastructure design cost
Capability creation and retention Strengthening of skills Data and knowledge sharing with customer Reuse of past projects and knowledge	Implementation costs Solution implementation cost Resource training cost
Asset and resource management Resource (asset/employee) efficiency Resource (asset/employee) flexibility	Operating costs Product delivery cost Service delivery cost Infrastructure operating cost
Market Acquisition of new customers Acquisition of new markets Retention of existing customers	Disposal costs Product and material recycling cost Disposal cost
Environment Consumption of natural resources Recycle/reuse of parts	Costs to comply with regulations Cost to comply with regulations
Value chain Generation/exploitation of alliances in the value chain Efficiency of the supply network	Network costs Coordination cost Information sharing cost
Innovation Innovation level	

Table 4. Second step value criteria for the customer

BENEFITS	COSTS
Capability creation and retention Strengthening of human skills Strengthening of company infrastructures Data and knowledge sharing with customer	Acquisition costs Service acquisition cost Product acquisition cost Solution acquisition cost
Asset and resource management Asset/resource safety and security Asset delivery performance Asset/resource efficiency and flexibility	Operating costs Product delivery cost Service delivery cost Infrastructure operating cost

Business opportunity
Revenue generation opportunity
Partnership generation opportunity
New market generation

Network costs
Coordination cost
Information sharing cost

Environment
Lifecycle of product
Consumption of natural resources

Costs to comply with regulations
Cost to comply with regulations

Intangibles
Experience
Empathy

Value in use
Reliability
Ease of installation
Solution flexibility and customization

In the interviews, the six concepts selected from the previous step have been evaluated. Benefits have been ranked with a score from 1 to 5 (1 the concept does not provide benefit; 5 the concept provides high benefit) while costs are ranked with a score from -1 to -5 (-1 the concept impact on costs is negligible; -5 the concept impact on costs is largely exceeding the company budget). If the criterium is not applicable for the analyzed concept “0” is assigned.

The answers have been analyzed thorough TOPSIS method and the results are reported in the graph shown in Fig. 2. As above mentioned, TOPSIS technique measures the shortest distance from a positive ideal solution and the farthest distance from a negative-ideal solution. The first maximizes the benefit criteria and minimizes the cost criteria, whereas the second maximizes the cost criteria and minimizes the benefit criteria.

Thus, based on the company inputs, the chart has been divided into the following 4 areas:

- Concentrate here: the concepts provide high value for both customer and provider and then they should be those ones to design and implement.
- Keep up the good work: the concepts provide high value for the customer but not for the provider. Thus, they should be further refined and modified to increase the provider value.
- Low priority: the concepts generate relevant value only for the provider. The concepts in this quadrant should be discarded.
- Possible Overkills: the concept provides low value for both provider and customer. The concepts in this quadrant should be discarded.

As for the previous phase, the quantitative analysis has been complemented with a qualitative analysis of the single criteria.

In particular, the criteria scores have been analyzed more in detail in order to understand which were the most relevant benefits and costs from both customer and company point of views. This analysis is essential to understand the actual company perspective, and which can be the barriers to servitization. For example, the target company is mainly worried by design and implementation costs of the new PSSs while the main benefits perceived are the company image and brand strategy. At the opposite, from installer point of view, costs are not a big issue while the main benefits are related to intangibles and value in use criteria (i.e. experience and ease of installation).

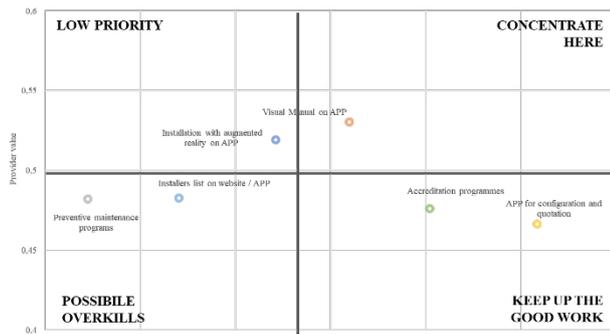


Figure 2. EVA step 2 results

This analysis led to the final selection of solution concepts to be developed and added to the PSS portfolio of the target company. The most valuable PSS is the delivery of *visual manuals* (preferably through app). *Accreditation programs* and *app for configuration and quotation* would also provide high value for the customer, but the concept should be further refined to increase the value for the company. From the qualitative analysis of the EVA criteria it emerges that the company is still anchored to a product-centric approach, and many are the internal barriers that could curb a successful servitization. Indeed, the costs of the services are seen as insurmountable even where the benefits are perceived as interesting. This has led to the definition of a fairly traditional PSS portfolio with a strong focus on product. In fact, although the long-term vision of the company provides for the introduction of services, the middle management is still too focused on product innovation and the PSS concepts assessment has confirmed the traditional vision linked to the sale of product with an analysis mainly based on costs rather than on customer benefits.

5. Conclusion

Nowadays companies are struggling to move from a product oriented towards a more PSS oriented business model. Academic and scientific literature reveal that there is a lack of suitable methods, tools and methodologies to support early PSS design activities, integrating product and service concept since the beginning and evaluating early design concepts based on both customer needs and company profitability. This paper has proposed the adoption of the EVA method to fill this gap and has proved its validity implementing it in an Italian company in the automation control system industry. The analysis has led to the selection of one PSS concept to be added in the company portfolio and two to be further refined. The interviews and the implementation of the method has highlighted as a cultural change inside the company appears to be fundamental to successfully introduce PSS offering. Indeed, a willingness of the middle management to offer services that could change the habits of customers and could allow establishing a different relationship with them is still missing. Furthermore, also customers are perceived not very prone to services but still too focused on acquisition cost and selling price. In general, there is a lack of a long-term vision in which the relationship with customers can change and therefore the possibility of offering services effectively capable of anticipating their needs. Despite that, the implementation of this method has been a first

valuable attempt to change the mindset of managers, since it has allowed them to analyze their products from a different point of view and to design new solutions starting from customer needs rather than from technology and product innovation point of view.

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