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Assessing PSS from a multi stakeholders' perspective: the application of the EVA method in the airport context

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Abstract

Recent economic developments and the spread of technology are pushing companies toward the provision of complex and innovative Product-Service System (PSS). On the other side, information and communication technologies are enabling the identification of a plethora of PSSs characterized by different levels of integration among products, services and infrastructure. In this context, many companies are experimenting difficulties in selecting the proper PSS to be developed, that is the one that concurrently considers the needs of multiple stakeholders and a good engagement of them in the value creation and engineering process. This paper exploits the Engineering Value Assessment (EVA) method to support the evaluation and the assessment of PSS solutions in a B2C context where the management of multiple stakeholders' perspectives is of utmost relevance. To demonstrate the EVA method applicability, the airport context was selected as an example of system complexity since it involves manifold actors: passengers, airport and airlines. Four different PSSs for the self-drop bag were identified and further analyzed through the EVA method in order to identify which is the best one to be adopted in the studied airport in the north of Italy considering the preferences of the three actors: the passengers, the airport and the airlines.

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Keywords: Product-Service System; PSS selection; PSS assessment; EVA method; Airport

1. Introduction

Recent economic development and the spread of technology are pushing companies toward the provision of complex and innovative Product-Service System (PSS) [1] that are characterized by an intricate structure of product, services infrastructure and network. The increasing diffusion of technology is shaping the PSS evolution and business model definition [2]. As a result, information and communication technologies could enable a plethora of PSS characterized by different levels of integration among multiple products, services and infrastructure. In the light of this, many companies are experimenting difficulties in selecting the proper mix of product-service and technology to be adopted [3,4].

Furthermore, while engineering new solutions, the needs of multiple stakeholders must be met contemporarily, and a better engagement of customers and all stakeholders in the value creation and engineering process shall be pursued [5].

The abovementioned criticalities are further exacerbated in the B2C context characterized by high heterogeneity of customers and other stakeholders. Specifically, the airport context could be mentioned as an example of system complexity since it involves many actors exploiting and adopting different PSSs at different stages of the customer journey. Moreover, the airports are rapidly moving from being gateways for travelers, to representing large shopping and logistics hubs. This means that complexity in the airport context is further increasing, making their profitability the result of many conflicting objects. Indeed, the overall customer experience at airport depends on the action of multiple actors within the industry value chain [6]. Henceforth, during the development of new solutions in the airport context, it is nowadays crucial to understand and take into account the

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business environment and the conflicting objectives of the different actors.

In the PSS domain there exist few methods for the evaluation and the assessment of PSSs. However, the existing methods share two main issues [7]: i) lack a comprehensive analysis that holistically considers multiple stakeholders and, ii) complexity in computation and application. As summarized in [7], the majority of the works propose very complex computations (see for example [8] that are not in line with the needs of companies (cf. [9]). Most importantly all the approaches deal with the evaluation of PSS concepts from one single perspective (see for example [10]) Given these gaps, this work adopted the Engineering Value Assessment (EVA) method [7] which proposes advantages in managing multiple perspectives at the same time and in guiding the identification of trade-off between the multiple actors interested in a solution. Moreover, it boasts a relatively straightforward computation approach.

The EVA method [7] consists of two different phases aimed at the PSS analysis and assessment through multi-criteria decision-making method. It exploits the Pugh Matrix [11] and TOPSIS method [12] to recombine and prioritize PSSs and proposes the Importance Performance Analysis (IPA) matrix [13,14] to guide a trade-off identification between the evaluation from multiple actors. Given the complexity of the airport context and the capability of the EVA method to handle multiple stakeholders, the objective of this paper is the application of the EVA method into the airport context to verify its applicability in a B2C context and to verify if it could support the PSS analysis considering three different stakeholders. The remaining of the paper is structured as follows. Section 2 deals with the presentation of the case study context together with the description of the different PSS design alternatives. Section 3 illustrates the definition of the value criteria adopted during the assessment. Section 4 explains the EVA method application. Section 5 includes discussion and conclusions.

2. The self-drop bag PSS

Nowadays, "Commercial airports are under increasing pressure from both, passengers, airlines and shareholders to keep prices competitive and remain profitable. However, factors such as consumer trends, security developments and political changes, have made it much more challenging for airports" [11]. To overcome some of these difficulties, airports need to innovate by exploring new operating methods, technologies and processes. This paper focuses on the Orio al Serio Airport, in the north of Italy, that is also facing these difficulties and exploring innovative processes. It is the the third busiest airport in Italy after Roma Fiumicino and Milano Malpensa.

The studied airport, is currently exploring new solutions to be implemented. In particular, pushed by airlines and by the increasing number of passengers, it is revising alternative solutions to optimize the available infrastructure and to re-structure the baggage check-in process. This is a standard procedure that passengers have to follow to leave the baggage before a flight and it is carried out in every airport around the world.

Traditionally, the baggage check-in was carried out by the ground crew that verified passengers' documents and checked-in the passenger's baggage. In recent years, also thanks to the spread of new technologies, the self-baggage check-in, also called self-drop bag class, has been introduced in many airports. This new procedure to leave the baggage foresees that the passenger, by himself check-in the baggage into the airport.

The baggage check-in can be defined a "use-oriented" PSS since it is composed of a tangible product (the counter) sold with a mix of services and infrastructure (maintenance, software). The counter, is owned by the the airport that sells the functionality to the airlines. The airlines, in turn, pay for the number of available check-in according to the level of utilization (i.e. amount of time) of the check-in counter as agreed in the contract underwritten with the airport. The contracts are usually very customized and depend on the airport and on the airlines. The airport is also responsible of the maintenace and the overall upgrade of the physical and software infrastructure nevertheless the check-in service is managed by the airlines that use the PSS according to a pre-agreed schedule with the airport. According to the use-oriented business model scheme, the airport is able to generate more revenues providing technological and advanced PSSs to the airlines that, on the other hand can optimize the usage of their handling resources dedicated to the chek-in counters. According to the product and the infrastructure provided by the airport, the airlines can decide to perform the check in in the traditional manner or to offer to the outgoing passengers the possibility to autonomously use the counters and the related service.

In recent years, different kind of self-drop check-in have been introduced and many designs are available for the implementation of this new PSS. The Orio al Serio airport is experimenting some difficulties in identifying the one that best suit the specific context. To support that decision, this paper presents the application of the EVA method aimed at evaluating the different available alternatives considering three multiple perspectives: (i) the airport as the company entitled to handle the airport infrastructure and assumed to be the provider of the new self-drop PSS; (ii) the passengers as the users of the new solution; (iii) the airlines, as the third actor involved in the airport-passenger relation whose decisions and actions can significantly influence the self-drop setting. The airlines have been the final user of the self-drop PSS since few years ago.

2.1. The available self-drop bag PSS

As previously anticipated, there exist a variety of self-drop bag PSSs because they depend on the kind of products and services bundled in the solution. The product (the check-in counter) could be designed as a *retrofit* or a *new fit*. The *retrofit* design can be installed overnight onto existing airport check-in desks while the *new fit* is a structure designed to optimize the dropping activity. It is disruptive with the traditional paradigm of check-in counters. Regarding the self-drop PSS, the main process to be followed can be summarized as following: i) verify the passenger's boarding pass; ii) weigh the baggage; iii) issue the baggage check-in tag; iv) accept the baggage; v) deliver the baggage. These activities can be performed in *one step* or *two-step* according to the PSS proposed. In the *one-step* design, all the activities are performed in the same place where the baggage is injected into the baggage system and the counter supports the passenger in all the phases. For the *two-step* design, two different interfaces are required. The first three activities are performed through the so-called kiosks, while the bag is injected into the baggage system (fourth and fifth activity) thanks to a different interface. Hence, the combination of the two alternatives of each component results in four possible concepts: i) *concept 1*: retrofit, one step; ii) *concept 2*: retrofit, two-step; c*oncept 3*: new fit, one step; *concept 4*: new fit, two-steps.

Considering the variety of products and processes associated to the solutions, the four of them would have a different impact on the structure of the airport as well on the passengers' journey and on the airline ground operations. As a first step for the application of the EVA method, the main criteria to be adopted for the evaluation of the PSSs in the airport context were identified, as reported in the next section.

3. The evaluation criteria

The starting point for the evaluation of the self-drop PSSs, was the identification of the value criteria to be adopted during the assessment. Although a large number of works has been developed in the area of airport service evaluation, a complete set of criteria to be adopted in the area does not exist. Regarding PSS domain, a similar "issue" could be highlighted since existing works are all proposing a variety of drivers with different levels of granularity and detail. A summary of this is reported in [16]. However, while specific criteria for the airport context are not available, a specific analysis to define the criteria for the airport context were explored in this research.

Three main steps were pursued. *First* an investigation of the literature was performed to collect and summarize what are the relevant values (or criteria) used to evaluate services and PSS in airports from the perspective of the three main actors identified (the passengers, the airports and the airlines). S*econd,* the three sets of criteria gathered from the literature were further analysed to pursue an initial selection of the most relevant drivers. *Third,* the metrics identified were validated with expert people in the field.

3.1. Analysis of literature

Based on the three main actors identified (the passengers, the airports and the airlines) a specific area of literature was analysed for each stakeholder. At this first stage, general criteria for the analysis of services and PSS into the airport context were reviewed. I.e. "While considering the introduction of new PSS in the airport, what are the criteria that are used respectively by passengers, airports and airlines to evaluate such PSS?". The study of the literature followed a process of systematic review of academic and scholarly publications in the SCOPUS database.

Three keyword sets, (Table 1), were searched. Most of the words were tailed to the search operator (*) to include nearby terms (e.g., "metric*" for 'metric' and 'metrics'). The third keyword set included the word "service" instead of "Product-Service System" since the PSS concept is not yet common in the airport context. The research led to 554 documents.

The investigation was limited to the documents in English and Italian languages and to the types of documents equal to journal papers, book chapter, review and conference. The works were filtered in subject areas: Engineering, Social Sciences, Business, Decision Science and Economics, leading to 236 articles.

Table 1. Keyword search adopted in literature analysis.

Keyword Set1 (linked by OR)		Keyword Set 2 (linked by OR)		Keyword Set 3 (linked by OR)
Criter*		Airport*		service
Factor*		Airline*		performance
Metric*	AND		AND	
Measure*				
Indicator*				
Driver				

Then, the papers were further cleaned by title, 70 papers selected, and by abstract: the inclusion criteria cover 'relevancy of the described metrics for the airport system' and 'applicability to early design stage decision making'. 48 papers were kept after this filtering. The list was then screened on a full-text base, eliminating entries that did not explicitly refer to 'value metrics for passengers, airport or airline'. At last, the 34 remaining articles were complemented with other contributions through snowballing.

Only four articles were identified, and a final set of 38 papers was identified. The articles were further grouped according to the actor to which they refer to. Among them, 18 are related to the passengers' metrics, 13 documents are related to the airports' metrics and 8 are related to the airlines'.

The sum of the documents belonging to the three groups is 39 due to the fact that one paper simultaneously investigates the airport and airline values. To catalogue the different values, all the papers were classified into a specific table reporting the title, the authors, the year of publication, the macro categories adopted by the actor for the evaluation of the PSS (if expressed), and all the specific drivers pointed out by the article in relation to the category.

3.2. Analysis of value drivers

After an initial collection of literature, an analysis on the identified metrics was carried out to: i) avoid duplicates and relationship among the metrics, ii) propose metrics that allow considering both benefits and costs, iii) select the metrics that could be used effectively to evaluate service concepts before their actual implementation. Hence, three final lists of value drivers were outlined, one for each stakeholder (passengers, airports and carriers).

3.3. Validation of the value drivers

The final lists of value drivers obtained from the analysis described in paragraph 3.2 were finally validated through semi-structured interviews with experts. Three people, one for each stakeholder, were interviewed to assess the totality of the metrics and to highlight issues which otherwise may have remained undiscovered. The passenger set of drivers was evaluated with the support of the quality and customer relationship manager at the airport. The airport set was reviewed with the operations manager while the airline criteria were validated with the general manager of the handling company at the airport who has a twenty years' experience in airline management. The semi-structured format allows keeping the interviews focused on the topic of this study and to maintain consistency with the drivers selected by asking prepared questions. At the same time, open-ended questions and a non-judgemental approach ensured openness to new input from respondents [17]. The final sets of drivers are reported in Table 2, they include both the general category of value and the specific drivers for value assessment included in the macro category. This is in line with what foreseen by the EVA method (Figure 1). In bold characters, the category of value is reported, inside each of them the specific drivers are listed.

4. Self-drop solutions evaluation through the EVA method.

To identify which PSS, among the four available, is the one that best fit the requirements of the analysed airport, the EVA method [7] (figure 1) was applied.

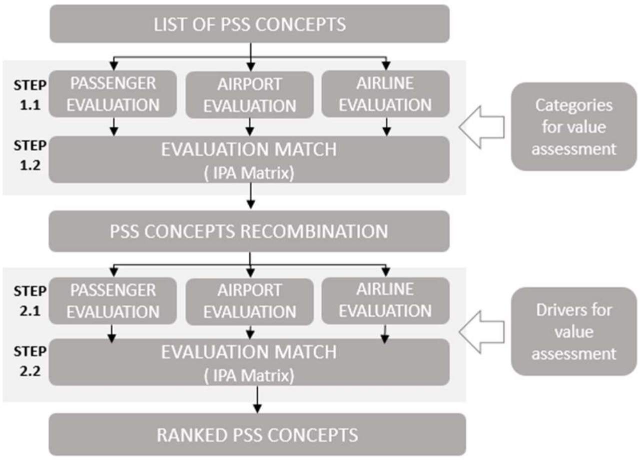

Fig. 1. EVA method summary.

As shown in figure 1, the main feature of the EVA is the capability of considering multiple perspectives during the evaluation and providing a trade-off between them. In the specific case at the analysed airport, three multiple perspectives were analysed: (i) the airport; (ii) the passengers; (iii) the airlines.

The EVA method is composed of two independent steps. The first aims at evaluating the PSS concepts considering their strengths and weaknesses. This enable the recombination of the concepts and the development of new solutions. The second step focuses on a more detailed assessment of the PSS concepts emerged from the first step. It enables the prioritization of the concepts pointing out the one that maximises the values of all the three stakeholders by considering the specific criteria identified previously. As shown in figure 1, the first step uses general criteria for value assessment while the second foresees the use of more detailed value drivers that help in gathering the multifaceted dimensions of value.

Regarding the self-drop bag at the studied airport, the design alternatives (concepts) refer to a specific PSS (i.e. the self-check-in) and their design is clearly defined. The airport management team responsible to evaluate the different PSS solutions was not interested in any innovation or changes to the concepts already available into the market.

Table 2. Summary of literature drivers for the value evaluation for each actor.

Passengers
Problem resolution
Promptness of handling requests and complaints
Helpfulness of handling requests and complaints
Performance
Efficiency
Waiting time
Service time
Responsiveness - promptness
Accuracy - reliability
Ease of use
sense of safety and security
Convenience
Opportunity to book and pay through internet
Service frequency
Schedule flexibility and convenience
Network externalities
Employee
Appearance
Knowledge
Promptness - responsiveness of providing service
Courtesy
Accessibility
Clearness and accuracy of information
Promptness and timeliness of information
Availability
Walking distance
Image
Appearance- modernity- attractiveness
Cleanliness
Environmental impact
Price
Price

Airport
Revenue
Aeronautical revenue -passenger
Aeronautical revenue - airline
Non-aeronautical revenue -parking
Non-aeronautical revenue – shops
Non-aeronautical revenue – advertisement
Reliability and safety
Number of accidents/incidents
Time to resume normal service
Image
Number of jobs created
Technology appearance
Strategy
Alignment with strategy
Cost
Investment cost
Operational cost
Disposal cost
Social impact
Number of community complaints about operations
Natural resources consumption

Airlines
Revenue
Load/yield factor
Image
Number and type of complaints
Technology appearance
Impact on operations
Punctuality
Energy efficiency of installations managed
Cost
Airport fee
Operational cost

Advertising expenses

Hence, only the second step of the EVA method was applied. The perspectives of the three stakeholders about the 4 design concepts were analysed in relation to the respective definitive set of metrics (documented in the previous section) using the Theory of Order Preference by Similarity to the Ideal Solution (TOPSIS) technique. Then, the scores gathered from the multiple perspectives were matched through the IPA matrix.

4.1 The Concept evaluation through TOPSIS

Based on the EVA method structure, the identified concepts were analyzed through the adoption of TOPSIS method [9]. This evaluation was repeated three times, one for each actor analyzed.

First, for each criterion, a weight was assigned on a whole of one hundred percent. Then, for each concept, a score with respect to each criterion was assigned through a 5-point scale. "0" means the concept does not provide any value associated with the criteria while "5" indicates that the PSS contributes excellently in providing the value. Conversely, for the criteria recognised as costs, negative scores were assigned. At the conclusion of this first step, a matrix composed of *m* criteria (rows) and *n* alternatives (columns) was obtained. Evaluation tables are not available here for space reason but are available upon request to authors.

The evaluation tables were then used to compute the TOPSIS algorithm based on the following three steps.

- Each element of the evaluation matrix was normalized to obtain the normalised evaluation matrix;
- Considering the weight of the criteria, the weighted normalized matrix was computed;
- The worst and the ideal solutions are identified considering the scores assigned with respect to each criterion;
- Finally, to rank the alternatives, the distance to the optimal solution and to the worst solution is calculated.

Table 3 summarizes the results obtained for the calculation of the concepts scores from the airport perspective, d_{bj} represent the distance from the best solution, d_{wj} indicates the distance from the worse solutions and s_{wj} summarizes the similarity to the ideal solution calculated as the ratio between d_{wj} and (d_{wj}+ d_{bj}). The definition of the scores and of the weights were gathered from the same three experts interviewed to validate the lists of criteria.

Table 3. Summary of TOPSIS results for the airport perspective.

	Concept 1	Concept 2	Concept 3	Concept 4
d_{bj}	0.008768	0.006738	0.001886	0.001954
d_{wj}	0.001906	0.001935	0.006982	0.008524
s_{wj}	*0.178562*	*0.223104*	*0.78728*	*0.813470*

4.2 Concept selection and trade-off identification though IPA matrix.

As a result of the evaluations, each concept received three scores: one related to the customer perspective (passengers), the second related to the PSS provider (airport) and the third related to the third actor involved (airlines). To facilitate the visualization of the value of each concept, the scores were positioned in a 3-dimensional map and visualized thanks to the IPA matrix represented in Figure 2.

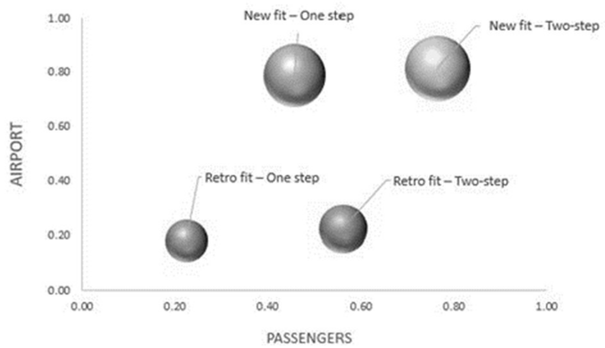

Fig. 2. Final representation of the results of the EVA application in the IPA.

The IPA features an "importance" axis that displays the customer (passengers) score, and a "performance" axis that displays the expected value for the provider (airport). A further dimension to visualize the scores representing the third stakeholder's (airline) is shown by the magnitude of the points representing the various concepts under analysis. Clearly, the bigger the size of the point is, the higher is the value assigned to that concept from the stakeholder perspective.

According to the PSSs positioning in the figure, it is possible to state that the *passengers* prefer the two-step approach. Even if the one step could be thought as the preferred solution since the passenger prefer doing activities in one shoot waiting in one queue, analyzing all the values the result is that they prefer the two-step design. Indeed, the two-step design provides higher value in many drivers like problem resolution [18,19], efficiency, service time, responsiveness [18,20] and ease of use. In addition, the two-step design offers higher schedule flexibility[19,20] during the check-in process and more accurate and timely information[18,21], both values considered very relevant by the passengers. Moreover, it is noticeable that the passengers recognize as more valuable the new fit than the retrofit solutions due to its modern appearance and attractiveness [21]. Hence, the degree of novelty and innovation can increase the value of PSS around the 20%. However, the most significant driver used by the passengers to choose between the alternatives remains how the process is delivered. Having a smooth and regular process allows the solution to score above the 0.5 on a maximum total score of 1. Indeed, the retro fit – two-step alternative (0.56) is still the preferred with respect to the new fit – one step concept (0.46).

Regarding the *airport's perspective*, the new fit solutions are those closer the ideal solution (top corner of the map) even if they require higher investment cost. Indeed, the new fit allows to satisfy better the necessity of appearing a technological innovator to attract more airlines and passengers. Indeed, airlines are fascinated by technological airports since they allow to save costs and attract more passengers[22]. In addition, the new fit designs allow the airport to rethink the terminal layout dulling the current congestion level of the areas. Moreover, it is possible to conclude that, from the airport perspective there isn't a clear difference between the one-step or two-step PSS.

Dealing with the third stakeholder perspective, *the airlines*, it could be observed that the new fit PSSs also meet their preferences. As for the airport's perspective, the airlines are more interested in using advanced technologies to enhance their images and to save operational costs. In addition, no noticeable difference between the one-step and two-step alternatives designs is visualized.

According to the evaluation of the four PSS and to the results visualization in figure 2, the Concept 4 "new fit – two-step" concept is the one that maximizes the value for all the stakeholders involved in the analysis. Convergence between the evaluations could be identified since this alternative obtained the highest score from all the stakeholders.

The results obtained from the analysis were appreciated by the airport management that underlined the importance of meeting multiple actors need while introducing new solutions. It is noticeable that the insights and the suggestions provided through the EVA method were evaluated consistent and valuable from the people involved. The method takes into account all the relevant values for the airport management team while allowing to take decisions through a systematic process.

5. Conclusions and further developments

The air travel industry has been depicted as a great example of the complexity of value chains. Moreover, the airports are rapidly moving from being gateways for travelers, to represent large shopping and logistics hubs. In this complex environment, the identification of new PSS to be introduced is critical due to the plethora of actors involved and their divergent needs and requirements. To cope with this issue, this paper proposes the adoption of the EVA method to support decision making during the PSS selection phase. The EVA method indeed allows the simultaneous evaluation of new PSSs from multiple perspectives and guides decision makers in identifying trade-off among the multiple actors interested in a solution. Moreover, thanks to the Importance Performance Analysis it visualizes such tradeoff.

The EVA method was adopted in the Orio al Serio Airport for the selection of the most suitable self-drop check-in PSS. Four different PSSs were analyzed considering three multiple actors, i) the passengers, ii) the airport and iii) the airlines. The results of the analysis through the EVA method shed light on the benefits that can be achieved by all the actors with the introduction of the "new fit-two step" PSS.

Further analysis could be carried out to deeper explore the study. For instance, a sensitivity analysis, changing criteria weights could be included in the proposed method to observe how the concepts evaluation change with a change in the scores and in the weight of the criteria.

Additional analysis and validation of the identified criteria could be beneficial to further verify the initial list adopted in this case. From what concern the self-drop-bag PSS concepts, the application of the first step of the EVA method could be beneficial to identify new and innovative concepts for self-drop bag that are currently not available among the best practices.

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