Adopting a Multi Criteria Decision method for the introduction of PSSs in the smart city context

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Abstract: The development of technology, coupled with the economic and the environmental changes, fostered interest in “smart cities” concept, that is cities where “investments in human and social capital linked with traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance”. In this direction, the city of Bergamo is approaching the smart city paradigm proposing new services and innovative solutions aiming at reducing costs and resource consumption, and at shortening the distance between citizens and city government. During a project with the University of Bergamo, many possible solutions to comply with this paradigm were highlighted. Budget constraints spurred to compare the ideas, and to select the most valuable to be implemented first. In order to facilitate the ranking and the prioritization of the ideas, a two-step assessment method based on Importance Performance Analysis (IPA) developed in the area of Product-Service System was applied in this study. The method, based on Multi Criteria Decision Making mechanism, is composed of two different steps, focusing on two different levels of detail, and it proposes specific evaluation criteria for the providers (i.e. the municipality) and for the customers (i.e. the citizen). The contribution of this study is twofold: first, it complements the IPA-based multi criteria decision-making method with the definition of specific evaluation criteria for external stakeholder that play a crucial role into the smart city paradigm; second, it describes the application of the method for the selection and prioritization of smart city alternatives in Bergamo context.

Keywords: Product Service System, Multi Criteria Decision Making, Smart city, Solutions selection

1. Introduction

Nowadays, 54% of the world's population lives in urban areas, a proportion that is expected to increase to 66% by 2050 (United Nations, 2014). The raise of urban population leads to the expansion of the traffic congestion, pollutants emissions, wastes and social iniquities (Kim & Han, 2012): if not controlled, these effects may worsen the living conditions of citizens. The level of complexity associated with these issues is high; it substantially concerns multiple stakeholders that have contrasting interests, high levels of interdependence, competing values, and social and political relationships (Nam & Pardo, 2011). Trying to address this problem, the new urban paradigm of “smart cities” born. Smart cities can be defined as places where “investments in human and social capital linked with traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance” (Caragliu, Del Bo, & Nijkamp, 2011). In this direction, many cities are moving toward the provision of services offered to citizens according to the six traditional pillars of smart cities indicated by the European Union: i) *smart economy* (e.g. private-public cooperation, development of social incubators), ii) *smart mobility* (e.g. Intelligent Transport System to improve urban mobility, decreasing of environmental impacts), iii) *smart environment* (e.g. reducing pollutants emissions, promoting the use of renewable source, monitoring energy consumption), iv) *smart people* (e.g. networking and communication, sharing data, security and protection of sources, initiatives to overcome digital divide), v) *smart living* (e.g. co-working spaces, living-lab, cultural initiatives, crowdsourcing co-design), and vi) *smart governance* (e.g. involving citizens on topics of public relevance, on-line document). Consequently, a smart city should be “able to optimise the use and exploitation of both tangible (e.g. transport infrastructures, energy distribution networks, natural resources) and intangible assets (e.g. human capital) (Neirotti et al., 2014). Therefore, every city should move toward the provision of services that can be offered to citizens considering all the previous mentioned aspects. In fact, it is possible to observe how in recent years the interest on smart cities, citizens and community integration, sustainable development is increasing, and a relevant number of cities is pushing the interaction among the city features (i.e. monuments, transportation systems) and the citizens. This integration is also facilitated by the increased number of Information and Communication Technologies (ICT). Social networks and mobile applications are playing a crucial role in such integration, acting as services enabling the interaction between the city spaces and the community. For instance, Desk Near Me (https://desksnear.me/) allows people to rent desks for few hours or days and select the location directly online, monitoring instant availability and prices. Another example is Laundry View (http://www.laundryview.com) that connects washing machines to the Internet, allowing users to check, or be notified, about the availability of the washing machines. Furthermore, consumers can report incidents or give comments/suggestions to the service provider (Valencia et al., 2015). In other words, the goal of the smart city is to "deliver the right services and deliver the services right all the time to all users by the same artifact: city" (Zhang, et al., 2014).

This integration of products, services, platforms and technology in a solution reflects the Product-Service System (PSS) concept (Mont, 2002). Indeed, recent researches refers to this concept as "City-Product Service System" (Zhang, et al., 2014) or "Smart Product-Service Systems" (Valencia et al., 2015).

The main issue associated to these Smart Product-Service Systems is that they are complex to implement and to analyze. In particular, when different solutions are available and the budget is limited, municipalities experiments some difficulties in prioritizing the solutions and their implementation. Multiple disciplines and stakeholders are involved and this makes their evaluation critical since it is difficult to estimate the impact under various circumstances. Based on this, the exploitation of the engineering approaches developed in the PSS field such as multi criteria decision making boasts great potential to improve the selection process since the initial stage.

On these premises, this paper focuses on the application of a multi criteria decision-making (MCDM) method, developed in the PSS area, to guide the assessment of possible PSS ideas in the Bergamo smart city, and to prioritize their implementation into the local community.

2. Bergamo smart city

Bergamo 2.035 is a research program on smart cities started in 2013, led by the University of Bergamo in collaboration with the Municipality of Bergamo, Harvard GSD and a private investor, Italcementi Foundation (AA.VV., 2014). The main goal of this research project is to find solutions able to improve the urban community life in all the above-mentioned pillars of the smart city. The Bergamo 2.035 project focuses on a multidisciplinary approach that increases the variety and thus the complexity of the solutions proposed, but also enhances new values and offer for the citizens. The project was developed in three phases. A first analysis phase, in which researchers from different disciplines shared a common research platform highlighting the evolving trends of urban environments. A second discussion phase, in which the evolutionary trends and the main problems of each sector have been discussed with the stakeholders. In this step, the key topics emerged were all the technological, environmental, social and economic aspects interacting with the city and the territory. A third development phase, during which some project ideas have been developed. This third phase ended in June 2014, and from that moment efforts have focused on spreading these ideas into the community of citizens and stakeholders.

As a major outcome of the project, many ideas and solutions have been proposed, each characterized by different investments, advantages, complexity and scope. Considering a "one shot" implementation of all the solution as not economically feasible, one of the main difficulties encountered during the project was to support the municipality and the stakeholders in comparing and prioritizing the solutions, that presented different degrees of feasibility and impact. Moreover, given the different level of technology and the involvement of stakeholders required by each solution, it was also difficult to understand which could be the less expensive solutions in terms of capital and efforts needed, and which the easiest to implement. Then, some focus groups with expert researchers, municipality responsible and additional stakeholders identified the most relevant solutions among those proposed (table 1).

Table 1 Smart City Solutions for the city of Bergamo

Smart City Pillars	Solutions proposed	Description
Smart Mobility	01. Smart parking management	Possibility to remotely find an available parking space and pay for it through an app.
	02. Electric buses	Introduction of buses with electrical engine in the local public transportation fleet.
	03. Smart sensors installation	Smart sensors for controlling traffic flows in the city center in order to better manage traffic movements in the city.
	04. Smart loading and unloading areas	Possibility to equip the loading-unloading areas with sensors and a management system that allows the remote booking by the carriers.
Smart Environment	05. Smart lightening	Convert the traditional city lighting system to a smart lightening system, with low-power lamps and people's detection sensors.
	06. Electric charging station	Build a network of electric charging station for e-vehicles.
Smart People	07. Smart aging service	Services that increase the city liveability for elderly (e.g. benches, anti-slip sidewalks, places for socialization).
Smart Living	08. Wellness paths	Paths specifically designed for citizens who wish to play outdoor sports activities in the city.
Smart Governance	09. Interactive municipality portal	A municipality internet portal that allows the citizens to obtain most of the available documents on-line by avoiding physical visits to municipality offices.
Smart Economy	10. Bergamo tourist card	A tourist card that lets access all the museums and city attractions, and get discounts at cafés, restaurants and shops.

They have been recently at the center of the local public debate, but the meetings with experts did not provide any common perspective on the selection among them. Different experts and/or stakeholders shared different opinions but, since they adopted different evaluation criteria, it was not possible to identify a shared understanding. Therefore, this work aims to propose a decision support method, currently adopted in the PSS research domain to prioritize solutions based on MCDM. The method would help in considering the solutions under multiple perspectives and criteria and in identifying a tradeoff, figuring out which of the solutions simultaneously meet the expectations of suppliers (e.g. the municipality), users (e.g. citizens, tourists) and stakeholders (e.g. shop owners). Then, in order to verify its applicability in the smart city context, the exploitation of the method into the Bergamo municipality is described.

3. The IPA-based multi criteria decision-making method

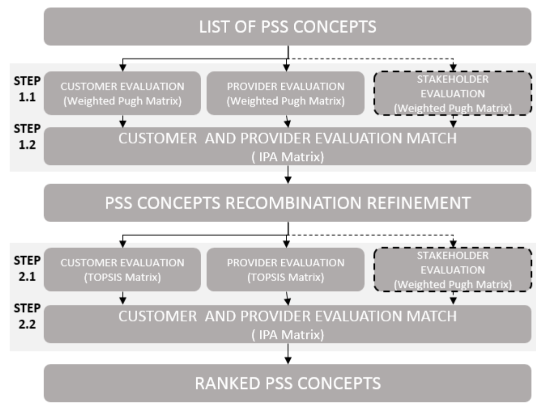
PSS research domain presents many works in the area of PSS evaluation. Most of the works related to the evaluation of solutions (Sakao & Lindahl, 2012) (Lee, Geum, Lee, & Park, 2015), however, refers to the assessment of the ideas only from the customer perspective without considering the benefits generated for the provider. In some cases, researches (Yoon , Kim, & Rhee, 2012) (Xing, Wang, & Qian, 2013) consider both the satisfaction of the customer in relation to a solution and the associated investment and costs for the provider, but they fail in integrating the two perspectives as a mean to find proper trade-off and make decisions. Other approaches (Peruzzini & Germani, 2014) (Shimomura, Hara, & Arai, 2008) (Kimita, Shimomura, & Arai, 2009) propose very detailed procedures for the evaluation of different solutions, also analyzing the entire lifecycle of an alternative. However, they require substantial input data that are not compatible with initial stages of analysis. I.e. defining precise costs and investment for the 10 different alternatives, could not be feasible and requires lot of time and monetary investment. Such information could be collected maximum for two concepts.

In addition to the abovementioned works, the Importance-Performance Analysis (IPA) based MCDM method (Rondini, Bertoni, & Pezzotta, 2017) has been specifically developed for the early stage of PSS design with a limited amount of information and data. Moreover, it focuses on the immediate visualization of the tradeoff between customer and provider perspectives, to guide cross-functional design team in progressively recombining solution principles, and in identifying the most valuable solutions. For these reasons, it has been selected to support the current research.

The overall MCDM method, proposed by (Rondini, Bertoni, & Pezzotta, 2017) is based on two steps, completed by a representation of the results in an IPA (Martilla & James, 1977) map that has been adapted to feature an “importance” axis that displays the customer analysis results, and a “performance” axis that displays the expected value for the provider. However, given the central role that stakeholders play inside the smart city context, this work elaborates an extension of the work proposed by (Rondini, Bertoni, & Pezzotta, 2017) adding the stakeholder perspective into the analysis. Indeed, an appropriate stakeholders’ involvement, taking into account their needs and their opinions is a major cause of the success of an urban project (Holguin-Veras, 2008).

The overall method structure is presented in figure 1. The dotted boxes are the improvements related to stakeholders and specifically developed in the current study.

Figure 1: IPA based method structure. Adapted from (Rondini, Bertoni, & Pezzotta, 2017)



Step 1 can accommodate the analysis of PSS concepts that are extremely different, and that are almost impossible to benchmark quantitatively even with full information available. This step recommends the adoption of Pugh matrix, (Cervone et al., 2011) and is performed for customers, provider and stakeholders (in this specific case). A first overview of the results is showed in the IPA structure (step 1.2).

Going through the discussion in step 1, the concepts can be improved, re-worked or refined. Then, *step 2* can be performed, based on a deeper analysis of concepts and their features. This second step is boosted by the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (Behzadian, Otaghsara, Yazdani, & Ignatius, 2012) method. After the second step, a second visualization of the rankings on the IPA map (considering provider, customer and stakeholders’ perspectives) is provided. IPA-based multi criteria decision-making method structure is again adopted (step 2.2) to visually represent the concepts positioning and trade off among the three actors involved. It is worth highlighting that steps 1 and 2 are supported by specific evaluation criteria gathered from literature in the area. The criteria adopted for the first level are collected in table 2. For more detailed information about the criteria and the method refer to (Rondini, Bertoni, & Pezzotta, 2017) (Bertoni, Rondini, & Pezzotta, 2017).

The IPA structure to represent the information works as follow:

I. PSS concepts in Quadrant I have high value for both customer and provider. They are in general approved for being forwarded to the next step; still, further evaluation, improvements or developments are advised.

II. PSS concepts in Quadrant II have high value for the provider and low for customers. In Step 1, this highlights the opportunity for borrowing features from concurrent options to increase the latter. In Step 2, concepts in this quadrant are discarded if QI is not empty.

III. PSS concepts in quadrant III have low value for both the customer and the provider. Being worse than the baseline, it is suggested to kill their development already in Step 1.

IV. PSS concepts in quadrant IV have high value for the customer but low for the provider. In Step 1 (as for QII), these concepts are worth additional analysis and can be further modified to be increased later. In Step 2, concepts in this quadrant are discarded if QI is not empty.

In this paper, a third dimension (i.e. the stakeholders) has been added. Such dimension is represented with different sizes of the markers representing the different solutions: a larg size implies high importance for the stakeholders while a small size suggests low relevance. Consequently, the ideal situation is to position a solution in QI with a large size meaning high relevance for stakeholder, customers and providers. Of course, a plethora of situations could arise, given the combinations of the three dimensions. It is up to the municipality (or provider) to select the proper trade off among the proposed solutions. In paragraph 4, this MCDM method that could support solutions prioritization will be illustrated through an application of the method to the Bergamo smart city project.

3.1 Stakeholder evaluation criteria definition

In the current work, the IPA-based multi criteria decision-making method has been integrated with stakeholder evaluation of solutions as highlighted in figure 1. The original definition of the method proposes specific evaluation criteria to be adopted in each step (Bertoni, Rondini, & Pezzotta, 2017); therefore, in order to complete it with evaluation criteria for stakeholders they have been analyzed considering the limited existing literature in the area (Wolfram, 2016; Vernon *et al.*, 2005; Toor and Ogunlana, 2010). After a detailed analysis carried out in the form of a focus group between PSS and smart-city researchers, the decision criteria for the stakeholders of the IPA-based multi criteria decision-making method have been defined as in table 2.

As it is possible to observe, the evaluation criteria selected for the stakeholders are a mixture between the provider and the customer categories. For what concern the specific evaluation criteria for the second step, the same sub-criteria defined for the categories belonging to both the provider and the customer side are adopted. Due to space constraints, they are not reported here but can be find in (Bertoni, Rondini, & Pezzotta, 2017) looking at the specific categories of the first step.

4. Application of the IPA-based MCDM method to Bergamo smart city

The method, integrated with a third graph dimension and specific evaluation criteria, was applied to the Bergamo smart city project. The starting point was represented by the ten different solutions identified throughout the project development and summarized in table 1.This paper shows a first test of the research in the area, to verify the applicability of the method. In this former phase, the solutions were evaluated through focus groups with experts in different domains from the University of Bergamo leaving to a second part of the research the evaluation of solutions by real municipality, citizens and stakeholders. During the focus group three key perspectives were considered:

- Customers, i.e. Bergamo citizens
- Provider, i.e. the Bergamo municipality
- Stakeholders, i.e. all the people impacted by the smart PSS solutions. It is worth highlighting that in this initial analysis the only stakeholders considered were the shop owners, the only ones with an interest in all the proposed solutions. The discussion of each single solution with all interested stakeholders will be postponed to a future research step.

4.1 Step 1.1

The first step foreseen by the method is the evaluation of the solutions (table 1) based on the Pugh matrix (Cervone, 2009) and the criteria identified in table 2. All the solutions are evaluated in three different matrixes (one for the stakeholder, one for the municipality, and one for the citizens) considering the different criteria. In each matrix, each solution is compared for each criterion to a baseline solution and can have three different scores: (+), (-) or (0) if they are, respectively, better, worse or equal to the baseline. In this case, the Bergamo bike sharing system was considered as the baseline solution, i.e. the solution that is currently bringing value to all the actors analysed in the exercise. Note that, by definition, the baseline scores “0” in all chosen evaluation criteria. The scores are then weighted considering the criteria weight defined by the team. Due to space limitations, table 3 reports an excerpt of a weighted Pugh matrix (customer) including only few drivers and few solutions. The complete matrix is available upon request to the corresponding author.

Table 2 Evaluation criteria adopted in step 1. Extended from Bertoni, Rondini, & Pezzotta (2017)

Customer evaluation criteria		Provider evaluation criteria		**Stakeholders evaluation criteria**	
TOTAL FUNCTIONALITY	TOTAL EXPENDITURE	TOTAL FUNCTIONALITY	TOTAL EXPENDITURE	**TOTAL FUNCTIONALITY**	**TOTAL EXPENDITURE**
(C1) Product/ service value in use	(C8) Ownership cost	(P1) Business opportunity and ROI	(P6) Product/ service lifecycle cost	**(S1) Business opportunity and ROI**	**(S6) System/ infrastructure cost**
(C2) Business opportunity and ROI	(C9) Operational cost	(P2) Brand strategy	(P7) System/ infrastructure cost	**(S2) Customer and Stakeholder relationship**	
(C3) System convenience	(C10) Financial and opportunity cost	(P3) Customer and Stakeholder relationship	(P8) Financial and opportunity cost	**(S3) System convenience**	
(C4) Intangibles	(C11) Effort	(P4) Capability creation and retention	(P9) Effort	**(S4) Capability creation and retention**	
(C5) Capability creation and retention		(P5) Uncertainty/ risk		**(S5) Brand/ strategy**	
(C6) Brand/ strategy					
(C7) Uncertainty/ risk					

Table 3 Extract of customer weighted Pugh matrix

	Weight	Interac. tour	Smart light.	Smart load. unload.	Bike sharing
P/S value in use	23%	0	-0.23	-0.23	0
System convenience	18%	-0.18	-0.18	0	0
Intangibles	21%	0.20	-0.20	-0.20	0
Ownership cost	23%	0.23	0.23	0.23	0
Effort	15%	0.15	0.15	0.15	0
Score	100%	0.41	-0.23	-0.05	0

For example, considering "intangibles" driver the Interactive tour in Bergamo was assigned a "+1" score considering the experience that the customer can receive from the overall solution whereas "smart lighting" and "smart load and unload" score "-1" since the customer does not directly experience the benefits of the services. Considering "effort" and "ownership costs" all the three solutions in the table score "+1" considering that the investment related to these options are limited with respect to the initial investment required for bike sharing (bike, parking stations and system management). On the contrary the solutions presented required only an initial investment (e.g the smart lamps or the reservation system for load and unload areas).

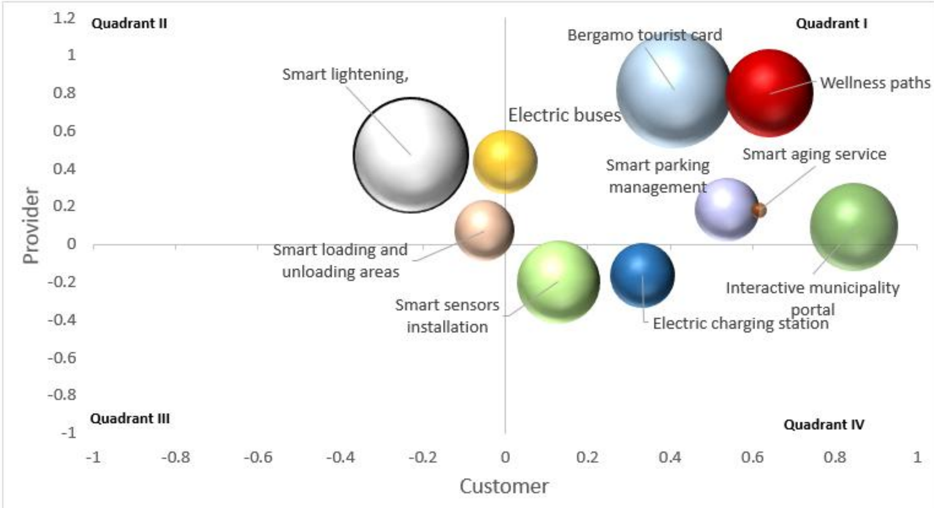
4.2 Step 1.2

The identified solutions have been positioned in the IPA graph (1st step) according to the scores obtained in the Pugh matrix. They are distributed in the matrix as in figure 2 and are split in three main categories as follow:

- Optimal. The solutions providing high value for both the customers, the providers and the stakeholders lay quadrant I and have a large size. Among them, it is possible to identify "Bergamo tourist card" (the most appreciated by the stakeholders); "wellness paths" and "smart parking management". In the same area, there is the smart aging service that, even if it satisfies the customer and provider requirements, seems not to guarantee any return for the stakeholders. "Interactive municipality portal" is good for stakeholder and customers but it is borderline for the provider. Indeed, it implies high investment to change the whole system and to train people in using it.
- Borderline. Some of the solutions are in a borderline position for both customers and providers. "Smart loading and unloading areas" provide limited value for the municipality (higher turnover of the parking for trucks) and for the customers (citizens do not care about the timing of refurbishment but perceive less traffic). Stakeholders, on the contrary would benefit from the quicker freights delivery; this explains the size of the point. "Electric buses" shares similar situation: customers do not gather any improvement in their everyday life. "Smart sensors installation" and "electric charging station" are in the opposite condition, boasting high validity for the customers but requiring too high investment and effort for the providers.
- Poor. "Smart lightening" is the only solution showing negative value. Indeed, only the providers get some benefits out of this solution: a relevant energy and consequent cost saving for the city lightening.

Based on this consideration, the preferred solutions identified for the second step are those described in the "Optimal" category. The only solution not selected for the second step is the "smart aging services" since it has a very limited relevance for the stakeholders (small size of the point).

Figure 2 Results at the end of step 1



The four “optimal” solutions selected for step 2 have been analysed in detail. Step 2 foresees the evaluation of the solutions based on a 5-point Likert scale, and based on more detailed evaluation criteria inside the categories in table 2. The evaluation was performed for the Bergamo municipality, the citizens and the stakeholders’ perspectives and based on each evaluation the solutions were assigned three scores. The results of the second step are represented in figure 3. As it possible to observe, the “Bergamo tourist card” seems the preferred solution. It offers quite relevant value to all the actors considered in the exercise.

The other three options, as displayed in figure 3, are not really different among each other. Indeed, it is not possible to highlight a clear ranking. The selection strongly depends on the priority that the decision-making team would assign during the decision. For example, if the municipality (in this case the decision maker) would like to favour its citizens, it would implement “smart parking management” before the other two solutions. If, instead, the priority is given to the shop owners, the wellness path would be the second choice.

These results reflect the analysis performed only for one category of stakeholders. Further research and development would consider all the stakeholders involved in a specific solution.

5. Conclusions

This paper shows the application of the IPA-based multi criteria decision-making method in a smart city context. In addition to the analysis from the customer and the provider perspectives foreseen by the original method, in this study the approach has been extended with evaluation criteria specific for the stakeholders (in this case the shop owners of the city) given their importance inside a smart city paradigm.

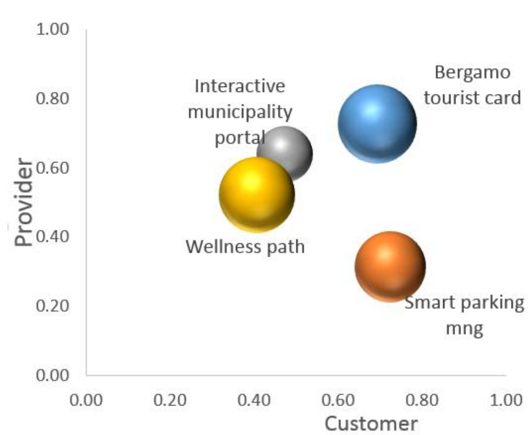
Then, the whole method was applied in the Bergamo smart city project and ten different solutions were evaluated based on the method specific criteria.

The IPA-based multi criteria decision-making method supported the identification of one solution that can potentially generate high value for both the citizens, the municipality and the stakeholders: the “Bergamo tourist card”. Among the remaining solutions, three of them showed relevant value, and for this reason they could be considered for future implementation.

Being a first application of the method in the smart city context, some limitations should be highlighted. First, people from academia only composed the focus group that evaluated the solutions, and the only stakeholders analysed were the shop owners. Moreover, during the analysis the experts shed light on one main weakness of the evaluation criteria available in literature: they lack a deep evaluation of the environmental and social implications that are connected to the possible solutions.

As a consequence, future developments would focus on the involvement of the Bergamo municipality and all the stakeholders that could be possibly impacted by the various solutions proposed. Additional researches will also focus on the environmental and social criteria of the method.

Figure 3 Results of step 2



References

AA.VV. (2014). Bergamo 2.035 A New Urban Concept. Milano, Wired. ISBN 978-88-89555-36-1.

Behzadian, M., Otaghsara, K., Yazdani, M., & Ignatius, J. (2012). A state-of the-art survey of TOPSIS applications. *Expert system with applications, 39*, 13051–13069.

Bertoni, M., Rondini, A., & Pezzotta, G. (2017). A systematic review of value metrics for PSS design. *The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems*, (p. in press). Copenhagen.

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology, 18*(2), 65-82.

Cervone, F. H."Applied digital library project management: Using Pugh matrix analysis in complex decision-making situations," *OCLC Systems & Services*:International digital library perspective, vol. 25, no. 4, pp. 228-232, 2009.

Holguín-Veras, J. (2008. Necessary conditions for off-hour deliveries and the effectiveness of urban freight road pricing and alternative financial policies in competitive markets. *Transportation Research Part A: Policy and Practice*, Vol. 42 No. 2, pp. 392–413.

Kim, H. M., & Han, S. S. (2012). City profile: Seoul. *Cities, 29*(2), 142–154.

Kimita, K., Shimomura, Y., & Arai, T. (2009). Evaluation of customer satisfaction for PSS design. *Journal of Manufacturing Technology Management, , 20*(5), 654 - 673.

Lee, S., Geum, Y., Lee, S., & Park, Y. (2015). Evaluating new concepts of PSS based on the customer value: Application of ANP and niche theory. *Expert Systems with Applications, 42*, 4556-4566.

Martilla, J. A., & James, J. C. (1977). Importance-Performance Analysis. *Journal of Marketing, 41*(1), 77-79.

Mont, O. (2002). Clarifying the concept of Product–Service System. *Journal of cleaner production*, 10 (3): 237-245.

Nam, T., & Pardo, T. A. (2011). Smart city as urban innovation: Focusing on management, policy, and context. *Proceedings of the 5th international conference on theory and practice of electronic governance*, (p. 185-194).

Nations, U. (2014). World urbanization Prospect. *Available at https://esa.un.org/unpd/wup/. Last accessed on 06th March 2017*.

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities, 38*, 25-36.

Peruzzini, M., & Germani, M. (2014). Design for sustainability of product-service systems. *International Journal of Agile Systems and Management, 7*(3/4), 206-219.

Rondini, A., Bertoni, M., & Pezzotta, G. (2017). An IPA based method for PSS design concept assessment. *The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems*, (p. in press). Copenhagen.

Sakao, T., & Lindahl, M. (2012). A value based evaluation method for Product/Service. *CIRP Annals, 61*(1), 51-54.

Shimomura, Y., Hara, T., & Arai, T. (2008). A service evaluation method using mathematical methodologies. *CIRP Ann.-Manuf. Technol, 57*(1), 473-440.

Toor, S.-R. and Ogunlana, S. O. (2010) 'Beyond the "iron triangle": Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects', *International Journal of Project Management*, 28(3), pp. 228–236.

Valencia, A., Mugge, R., Schoormans, J. P., & Schifferstein, H. N. (2015). The design of smart product-service systems (PSSs): An exploration of design characteristics. . *International Journal of Design, 9*(1), 13-28.

Vernon, J., Essex, S., Pinder, D. and Curry, K. (2005) 'Collaborative policymaking: Local Sustainable Projects', *Annals of Tourism Research*, 32(2), pp. 325–345.

Wolfram, M. (2016). Conceptualizing urban transformative capacity: A framework for research and policy. *Cities*, 51, 121-130.

Xing, K., Wang, H.-F., & Qian, W. (2013). A sustainability-oriented multi-dimensional value assessment model for product-service development. *International Journal of Production Research, 51*(19), 5908-5933.

Yoon , B., Kim, S., & Rhee, J. (2012). An evaluation method for designing a new product-service system. *Expert system with application*, 39, 3100-3108.

Zhang, Z., Ostros, E., Fougeres, A.-J., Bluntzer, J.-B., Liu, Y., Pfaender, F., & Tzen, M. (2014). City-Product Service System: a Multi-scale Intelligent Engineering Design Approach. *Moving Integrated Product Development to Service Clouds in the Global Economy*, 405-413.