Evaluation of services linked to the sustainability: a dynamic and multi-criteria approach

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The purpose of this paper is to study the challenge of the evaluation in the context of the services in the sector of environment and energy. Because of the specific nature of service innovation the traditional evaluation methods and measures are not able to capture neither the diversity of the innovations nor the multifaceted dimensions of performance. This paper aims to contribute to the need for a more diverse evaluation approach. We study the use of multi-criteria and system dynamic perspectives in the evaluation of services, and we develop a new type of methodology to evaluate their dynamics and multifaceted performance. (10 lines max)

1. Introduction

The focus in the definition and the evaluation of innovations has typically been on traditional S-T indicators orienting highly towards their technological and economic aspects. This approach has been criticized in the service studies (e.g. Djellal & Gallouj 2010, 2013; Toivonen 2010; Rubalcaba et al. 2012). Because of the specific nature of services, especially their immaterial and interactive dimension, the traditional evaluation methods and measures are not able to capture neither the diversity of the innovations nor the multifaceted dimensions of performance in the sector (Djellal & Gallouj 2013).

The increasing "servitization" of society has also put pressure to develop a more advanced approach to evaluation and in some recent studies (e.g. Djellal & Gallouj 2010, 2013; Rubalcaba et al. 2012), both the "plurality of methods" (Dyehouse et al. 2009; Williams & Imam 2007) and the basics for new evaluation criteria have been suggested. According to them, impacts should be assessed on the basis of a multi-dimensional approach to take into account their aspects of quality, reputation, social innovation and social value (Djellal & Gallouj 2010, 2013; Rubalcaba et al. 2012).

Systems thinking have often been applied hand in hand with these views. Reasoning is rooted in the modern "broad view on innovation" that highlights the interactivity (including multiple sources and actors in it), complexity and uncertainty of development and implementation of innovations. These arguments and perspectives affect both to the definition of innovations and to the evaluation of their effects and impacts (e.g. Kline & Rosenberg 1986; Lundvall 1992; Freeman 1991; Nelson & Rosenberg 1993;

Dosi 1999). And it directs to consider the dynamic nature, interrelationships and feedbacks between multiple actors within the process (Smith 2000; Edquist 2005; Cabrera et al. 2008).

The evaluation challenge concerns especially services that are linked to the sustainability and environmental issues. In such services, the technological perspective (especially "end-of-pipe" technologies) typically dominates discussions. However, the most urgent problems in the present society cannot be solved via the development of individual technologies or services. Instead, the focus is in service solutions which can be characterised as complex innovations integrating technological, non-technological and service-based elements and developed and implemented in the interaction with various actors (e.g. Djellal & Gallouj 2013b). The emerging role of service solutions is not sufficiently taken into account (Djellal & Gallouj 2010, 2013) in the current evaluation approaches.

This paper aims to contribute to the above described need for a more diverse evaluation approach. The objective in this paper is *firstly* to study the system perspective and the evaluation challenge in the context of service innovation and s*econdly* to develop a new type of *dynamic multi-criteria evaluation* approach*.* Suggested approach integrates the multi-criteria perspective (Djellal & Gallouj 2010, 2013) and system dynamic modelling (Sterman 2001). In the methodology multi-criteria perspective describes the various impacts by giving insight to different societal spheres and their principles and values in the sens of Economics of Convention (Gadrey 2005; Djellal & Gallouj 2010, 2013). System dynamic modelling pays attention to the interaction of various actors and their values in the evaluation situation (cf. Giddens 1987) and provides information how the system structure creates complex dynamic behaviour over time. It helps to explain the role of feedback loops between different actors and factors that promote or hinder the emergence of impacts.

The following research questions are guiding our work:

- *How and by what means should the outcomes and impacts be evaluated in order to take into account the multifaceted and dynamic nature of service innovations in the sector of environment and energy?*

- *What are the dynamic impacts of service innovations in the sector of environment and energy?*

As a result of our study we provide a two dimensional approach to evaluate the impacts of services. The focus is in understanding the dynamics of service creation in the environmental sector and the use of evaluation methods and indicators in it. At more detailed level, our study provides analytical material about complementarities and contradiction between different indicators. The results will illustrate how the technical and non-technical aspects of service innovations interact in the area of sustainability.

This paper is divided into three sections. The second section after this introduction is based on literature and discusses the current evaluation challenges in services. The third section presents the two main perspectives that we apply in our framework to evaluate the services. In the fourth section our case study context and methodology are described. In the fifth section we present the application of our frameworks and present the main results of our study. Final section sums up the discussion and makes the concluding remarks.

2. Theoretical background

2.1. System approach to services

The current social, economic, and environmental challenges are too big to be solved via individual product and service innovations created in individual organizations. Conversely, the challenges require various innovations and simultaneous development of organizations, technologies, services and multiple network relationships (Gallouj 1994, 2002; Windrum and García-Goñi 2008; Harrison et al. 2010; Rubalcaba et al. 2012). A crucial question is how to combine various innovations effectively and disseminate them rapidly on the basis of continuous interaction of different organizations. In other words, examining and developing innovations at the systemic level has come to the fore.

While innovations are increasingly combinations of many technologies, organizational changes and services, they are also embedded in a wider social environment which supports or restrains the development of new innovations. This wider context could be described as socio-technical system in which radical changes take place only rarely due to such phenomena as “path-dependency” and “lock-ins”. These concepts refer to the fact that past decisions and choices may steer and restrain new developments. Wide socio-technical change based on radical innovations becomes possible only if system faces e.g. a performance crisis which is not possible to solve with incremental improvements. In essence, a wide change requires complex interaction between actors, resources, institutionalised practises and regulation in a system. (Geels & Schot 2007; Geels 2004; Geels 2002) This means that we need a more systemic view and system oriented methods when we are assessing the dynamics and performance of the system. The focus on separate service or technological innovations needs to be replaced by a wider view taking into account the context and its complex interactions.

This kind of view is emphasized in recent studies on innovation ecosystems. The idea of innovation ecosystem emphasizes the idea of a system of various actors with mutual dependencies and causal linkages. For some writers the concept means innovator-distributor-retailer-end customer relationships and how the innovator/producer is dependent on other firms in its innovation and market activity (e.g. Adner 2012). Some other writers replace the whole concept of innovation system with the concept of innovation ecosystem (e.g. Heller 2013). The more elaborated versions of the concept refer to systems theory and use such concepts as co-evolution, co-specialization and co-opetition (Carayannis & Cambell 2009). In here we suggest that an ecosystem is a multi-actor and co-evolving system of private and public actors working together to create economic and societal advantage.

2.2. Evaluation challenge in services

For two decades, service studies and specifically the studies on service innovation have argued that the traditional tools, indicators and measures do not capture the performance, innovativeness and impacts in services (Sundbo 1998; Metcalfe & Miles 2000). A central background reason for the existence of the gap is the “assimilation” perspective adopted in the early service research (Coombs and Miles 2000;

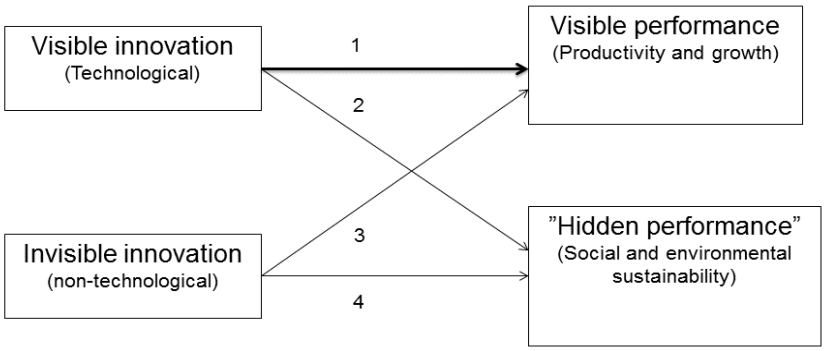
Gallouj 1994). This perspective analyzed services innovation as an imitation of technological and manufacturing innovations. The perspective was based on the traditional definition of innovation as an invention which results from an R&D project (Howells 2004). The linear, stage-gate model of an innovation process, which was raised to the position of a norm and marketed as a prerequisite for success (e.g. Cooper & de Brentani 1991), increased the bias.

These arguments and perspectives have been developed in the context of service innovations. However, they are strongly rooted in general innovation theories basing on the Schumpeter's definition of innovation that has afterwards been regenerated to "the neo-Schumpeterian" theory of innovation or a broader view of innovation (Lundvall 2007; Toivonen 2013). These traditions are interlinked by several common aspects that affect both the definition of innovations and evaluation of their effects and impacts. Important cornerstones are complexity and uncertainty of innovation process, intangible nature of innovation (focus in new solutions and processes) and systemic view of innovation encompassing multiple sources and actors taking part into the innovation process. (Kline & Rosenberg 1986; Lundvall 1992; Freeman 1991; Nelson & Rosenberg 1993; Dosi 1999). Also from the perspective of general innovation literature conclusion has been parallel: current practices in defining innovation and evaluating them do still follow the mainstream linear innovation thinking which simplifies too much the innovation process as well as the complex dynamics between actors contributing innovation (e.g. Smith 2000; Arnold 2004; Edquist, 2005; Smits & Kuhlmann 2004; Djellal & Gallouj 2010, 2013; Patton 2011).

In addition to the narrow view on innovation, the dominating view on performance is also mechanical and narrow. It is usually linked to the concept of productivity which refers to the linear and mechanistic input-output function (e.g. Djellal and Gallouj 2010, 2013; Kellog foundation 2004; Patton 2011). Its' traditional definition is unable to recognize the "hidden performance" concerning the societal aspects of services and innovations like equality, ecological sustainability and societal well-being. It also often excludes the aspect of social innovation (e.g. Rubalcaba et al. 2012).

Djellal and Gallouj (2010) have described the interaction between performance and innovation by referring to the visible vs. invisible nature of this phenomenon. Whereas technology-based innovations are visible, non-technological innovations are invisible. As regards performance, the authors link the visible-invisible dichotomy to short-term vs. long-term influences. Both in scientific and the managerial discussions, short-term influences of performance are often analyzed in terms of productivity and growth. Longer-term influences are increasingly analyzed in terms of environmental or social sustainability. There are four possibilities in the relationship between innovation and performance as Figure 1 illustrates (ibid., 668).

Figure 1. Innovation and performance gap in measurement of services (Source Djellal & Gallouj 2010)



The most apparent relation is between visible innovation and visible performance, but visible innovation may also lead to invisible performance by promoting the long term ecological sustainability or societal well-being. Correspondingly, invisible innovation may be a source of visible performance, i.e. growth and productivity, or promote sustainability.

The idea of "double gap" has been noticed to cause significant implications to public policies, which are still very technologist oriented and do not take into account the innovation and performance gap included. Thus, the invisible innovation and performance remain invisible in the policy making, causing problems – not only in the performance measurement as such – but also in target setting, and in steering and policy planning. In order to improve the situation, both the visible and invisible aspects in innovation and performance has to be included in an integrative way (Djellal & Gallouj 2010).

2.3. Opening the specific characteristics of service innovation and performance

After the realization of the narrowness of the assimilation view, two alternatives have gained ground. The first is the differentiation perspective – also known as the demarcation perspective (Coombs and Miles 2000; Gallouj 1994). It focuses on the specific characteristics of service innovation and has highlighted the difficulty of recognizing "newness" and its creator in the service context (Preissl 2000). The second alternative is an integrative or synthesis perspective (Cooms and Miles 2000; Gallouj 2002) which has become increasingly relevant due to the blurring lines between goods and services. It highlights the production and consumption that focus on integrated solutions and systems. The role of integrative services is emerging especially in the area of environment and energy (e.g. Hyytinen & Toivonen 2014).

Recently, these approaches have also been applied when searching better indicators for innovation and performance in services. The peculiar characteristics of services that specifically have been pointed out in this context are intangibility and the central role of interaction; the latter refers to the central role of co-production between the

provider, customers and partners. An important implication of intangibility is the difficulty of defining the "unit of output" and differentiating the product from the process. These aspects challenge the definition of innovation and quality improvements in it. Interactivity increases the complexity of the development of services innovations (Gallouj et al. 2013). Ignoring these complex and dynamic relationships (cf. Arnold 2004) is often linked to the traditional technologic measures and the linear innovation model (Smith 2000; Edqvist 2005; Ahrweiler 2010). It may lead to the oversimplification of the reality and to the biased understanding – not only of the impacts of services and innovations – but also of their drivers and dynamics (Arnold 2004).

New aspects in the analysis are inclusion of the time factor and the social nature of services (Djellal & Gallouj 2013). Time highlights the dynamic nature of services, focusing to their evolution over time. Considering time as a dynamic factor leads to the differentiation of short-term outputs from medium and long-term effects. The social nature of services derives from the fact that the value and benefit of services is always defined by users. This means that different actors have different values, and it is just this multiplicity of values which makes it necessary to include various criteria in evaluation. In addition to immediate users, it is important to take into account the multiple values of indirect users as well as those of different actors participating in the development, (Djellal & Gallouj 2010, 2013). Thus, in service innovation boundary lines are blurring – not only between products and processes – but also organizations often change simultaneously (PreIssl 2000). These kinds of combinatory innovations and their broader socio-economic impacts cannot be tackled on the basis of the traditional linear and industrialist models.

3. New framework for the evaluation of services

3.1. Multi-criteria approach to diversify the perspectives of evaluation

These above described challenges in measurement and evaluation of services intend to assess the performance and impacts on the basis of a multidimensional approach which takes into account the special characteristics of services as well as their aspects of quality and social value (Djellal & Gallouj 2010, 2012; Rubalcaba et al., 2012). Like writers have argued one potential and diversified way of analyzing the various impacts is by giving insight to different societal spheres "worlds of services" and their principles and values in the sens of Economics of Convention (Gadrey 2005; Djellal & Gallouj 2010, 2013).

In that model the outcomes are evaluated from the perspective of different goals encompassing both the traditional measures and the modern evaluation criteria taking into account the needs of knowledge society. In addition to the different target areas the model takes into account the long time-scale in the generation of impacts by dividing outcomes into the direct, short-term outputs and indirect, long term-outcomes (or impacts). The table 1 below illustrates the different worlds given the specific justification criteria related to the each of the worlds (Gallouj 2002; Djellal & Gallouj, 2013).

Compared to original model, we have made some minor modifications into it. Referring to the recent literature, the concepts concerning the aspects of social innovation, sustainability and responsibility should be taken more clearly into the consideration in the analysis of impacts (Rubalcaba et al. 2012; Djellal & Gallouj 2013). Our modifications concern especially the aspect of "the civic world" that originally was focused to social relations characterized by the ethical issues such as equal treatment and fairness. In this model we suggest to integrate the concept of societal value and responsibility into the idea of civic world and also rename it "responsible world". By the addition our aim is to better take into the account the aspects concerning the social innovations, environmental sustainability and societal well-being.

In the original model also the word of innovation (referring to creativity and inspiration) is differentiated. Because in our study the focus is in analysing service innovations, the specific perspective of innovation world is excluded from our table. Instead we clarify the different elements of innovation by adding that perspective horizontally to the table and by analyzing these aspects in the light of each world.

Table 1. Different justification criteria to evaluate outputs and outcomes of services (modified from Djellal & Gallouj 2010, 2013)

Worlds	**Industrial and technical world**	**Market and financial world**	**Relational and domestic word**	**Responsible word**	**Reputational world**
Innovation	Central aspects of the innovation from the perspective of each world				
Output (direct, short term) *Performance related*	Volumes, flows and technical operations	Value and monetary and financial transactions	Interpersonal and organizational relations, trust, quality of relationship	Values like sustainable development, responsibility, equal treatment, fairness and justice	Brand, image
Outcome (indirect, long term) *Performance related*					

Analysing the impacts from the perspective of different worlds makes visible the multifaceted nature of service innovations. However, analytical table remains static and does not increase understanding of their dynamic and complex nature. It does not show how the different impact criteria are mutually interlinked and may reinforce or contradict each other. This perspective in our framework is considered with the system dynamic modelling tools more carefully described in the following sub-chapter.

3.2. System dynamic modelling to evaluate the dynamics of services

One key insight behind systems thinking is that interlinkages between different elements in a system can create complex behaviour. This complex behaviour and non-linear nature in the evaluation of impacts can remain unnoticed if each component, such as the elements in the table above, is analysed separately.

Systemic problems cannot be identified directly because systems involve several characteristics that make them counter-intuitive. The following features are important to take into account in particular (Sterman 2001):

- Systems are tightly coupled, i.e. the actors interact with another and with the outside world. Feedback is a central characteristic of systems: decisions of the actors trigger others to act, which again alters the next decisions of the original actors.

- The central position of feedback makes systems history-dependent: taking one path precludes many others.

- Systems are non-linear, i.e. effect is not proportional to cause. It is also difficult to identify immediate cause-effect relationships – instead of that cause and effect are often distant in space and time.

- Systems are constantly changing at many scales that interact. They are also self-organizing and adapting: small, random perturbations are often amplified by feedback, and capabilities of actors change as a result of learning.

- Systems are policy-resistant: the complexity makes it difficult to understand the system and as a result many seemingly obvious solutions to problems fail. Time delays in feedback often mean that long-run response of the system is different from the short-run.

System dynamics (e.g. Sterman 2001) is a methodology that focuses on the underlying feedback structure of a system. System dynamics models incorporate causal connections between system elements that can be mapped using causal loop diagrams. Simulation modelling is used to understand how the interaction of various feedback loops creates certain dynamic behaviour (i.e. change over time in variables of interest). Even though the role of simulation is emphasized in the system dynamics methodology, even qualitative diagrams that show the interactions and feedback loops in a system can increase understanding of a system.

4. Case context and methodology

In our empirical analysis the focus is in service innovations in the area of environment and sustainability. According to some recent studies (e.g. Djellal and Gallouj 2010, 2013) the technologist perspective dominates typically the discussion of sustainable innovations although the role of integrative services is emerging especially in that area.

In this paper the focus is in analyzing the complex combinatory innovations. By that we mean that they all encompasses both technological and non-technological ingredients and are developed in the collaboration between multiple actors. As regards their targets they are aiming to tackle with prominent societal challenges, among which the environmental sustainability is primary. Specific service innovation we are interested in is *Environmental data platform* that aims to be a comprehensive platform to support continuous data gathering and real-time environmental monitoring, analysis and reporting.

Innovation has been developed in research and development program built on public-private innovation network that aim to promote systemic change in the field of environmental measurement in Finland. The program is carried out by a Strategic Centre for Science, Technology and Innovation – a new Finnish innovation policy instrument. The centres (abbreviated 'SHOK') operate in various industrial and service sectors as limited companies and are built on public-private partnerships. SHOKs can be characterized as public and private innovation networks generating complex and architectural services and innovations (Djellal & Gallouj 2013b).

We have applied the case study methodology and qualitative approach in our study. The main method in data gathering in our study was face-to-face interviews (30 in total). The interviews were gathered between February and June 2013. We applied snowball sampling in the identification of interviewees: the first respondents were Managing Director of Cleen Ltd and the Program Managers. Based on their suggestions, we thereafter selected the other interviewees among the members of the program consortiums. The final sample represented actors in the area of sustainable energy in a versatile way. It consisted of representatives of private companies (e.g. energy companies, companies developing environmental and industrial measurement), and universities and other public research organizations. All interviewees were managers or experts in their organizations and had a significant role in the research programs. Typically they were acting as a work package leaders or leading the service demonstration development.

For the data gathering we applied a semi-structured interview method: the topics were decided beforehand but within them the respondents were given a great deal of freedom (Bryman and Bell, 2011). The main topics focused on the manifestations of new innovative solutions within the programs, factors that promote or slow down their generalization, impacts of the innovations and their evaluation. The duration of the interviews ranged from one and half to three hours. All interviews were recorded and transcribed. Documentary data on the general development of energy technologies and markets were used as supplementary material.

In the analysis and interpretation of empirical data we applied the modified multi-criteria and system dynamic perspectives. We started the analysis by studying how the environmental data platform is impacting in a short and long term from the perspective of different worlds of services. In the analysis we are reflecting impacts both from the traditional and modern perspectives. Thereafter we moved to system dynamics modelling that aims to increase understanding of the dynamics in the system that results from interactions between the parts of the system – including reinforcing and balancing feedback loops.

4. Research results

Environmental data platform (table 2) is from an industrial perspective a prototype platform to gather and share environmental data. As a short term output it integrates real-time data sources (e.g. measured data of water quality and satellite data concerning environment and atmosphere) and provides visualized maps based on the data. In a long-term the goal is to integrate multiple data sources in it and provide "cloud-based comprehensive solution" to produce and share environmental data. Cloud-based solution would make the access to big data possible. In addition the architecture for real-time monitoring, analyzing and reporting will be created to improve the quality and reliability of environmental information, weather forecasts and warnings. New architecture helps in developing new end-user applications and thus accelerates business start-ups generation. Our respondents highlighted that services are in the central role in the development of comprehensive solution and new information architecture.

In the market world the main characteristic of the innovation is economically free access to the multiple data sources and especially to public sectors data. According to our interviewees free access to data is considered to be an important social goal and also a starting point for the development of data platform. In a long term goal is in opening new markets based on environmental analysis and in creation of new export possibilities.

Preferences and valuation principles in the relational world highlight the interaction between multiple actors and a role of end users is the development and use of service. Central innovative aspect here is the connectivity via one mediator to multiple data sources. As an output goal trust in the public-private innovation networks is enhanced. From the performance viewpoint enhances actors' connectivity and consolidates the networks. Long-term goal is to integrate citizens to the data provision, to better take into account the specific users' needs and requirements and hence provide personalized environmental data. That affects in a long term to users ability to be integrated part of the environmental data generation. Like our interviewees highlighted that development removers the clear distinction between the production and use of data: citizens are becoming data producers. That has been considered as a prerequisite for a systemic change in the sector.

From the perspective of responsible world overall sustainability is highlighted as a central value in development of new solution. The other value based aspects highlighted are transparency and the citizens' equal rights to participate to the data provision. Innovative aspect relates to the open and equal access to public sector data. As a short term goal platform enhances transparency, availability and multifaceted us of public data. As a long-term goal respondents have considered the possibilities to apply new end-user applications for example to the game and school worlds to support the environmental education and thus increase the awareness of environmental issues from the early age. From the performance viewpoint that may increase responsibility as a value in decision making in individual, firm and policy level.

Table 2. A multi-criteria framework to analyse the impacts of environmental data platform

	Industrial and technological	**Market and financial**	**Relational**	**Responsible**	**Reputation**
Innovation/Input	A prototype platform for environmental data gathering and sharing (integrating real-time data sources & data storage)	Free access to public sector data	Connectivity via one mediator to multiple data sources and end-users	Open and equal access to public sector data	Image as an innovation to enhance sustainability
Output (direct, short term)	Varied measured and satellite data concerning environment and atmosphere (e.g Weather radar visualised on the map)	Economical of free access to multiple environmental data sources	New connections and actor networks created (via new solution)	Transparency of public data; Easy access	Short term image
Performance related to output	Ability to process increasing amount of environmental data more quickly and more effectively	Reduced cost of sharing data Reduced cost of providing data	Increased connectivity between multiple actors	Increased transparency of public data Increased availability and better use of public data	Improvement/change in reputation and image
Outcome (indirect, longterm)	"Cloud-based comprehensive solution" for producing and sharing environmental data Architecture for real time environmental monitoring, analysing and reporting, bid data New end-user applications created New start-ups crated; new jobs	New market opening based on environmental monitoring New opening export possibilities	Integrating citizens and citizens' requirements to the data provision "Users as a data providers" (*Social innovation*) Personalised environmental data Trust	Equality in sharing information (data) Quality controlled data Platforms applied e.g. in education: environmental education and awareness	Long-term reputation and image
Performance related to outcome	Improvements in weather forecasts, environmental information and warnings Increased quality and reliability of environmental data Increasing number of business start-ups based on environmental data; Increasing number of new jobs	Improvements in the generation of various types of revenues based on environmental data	Increased usability of environmental data /knowledge Increased trust	Increased awareness of environmental issues Increased responsibility in decision making (individual, firm and policy level)	Long-term improvement/change of reputation and image

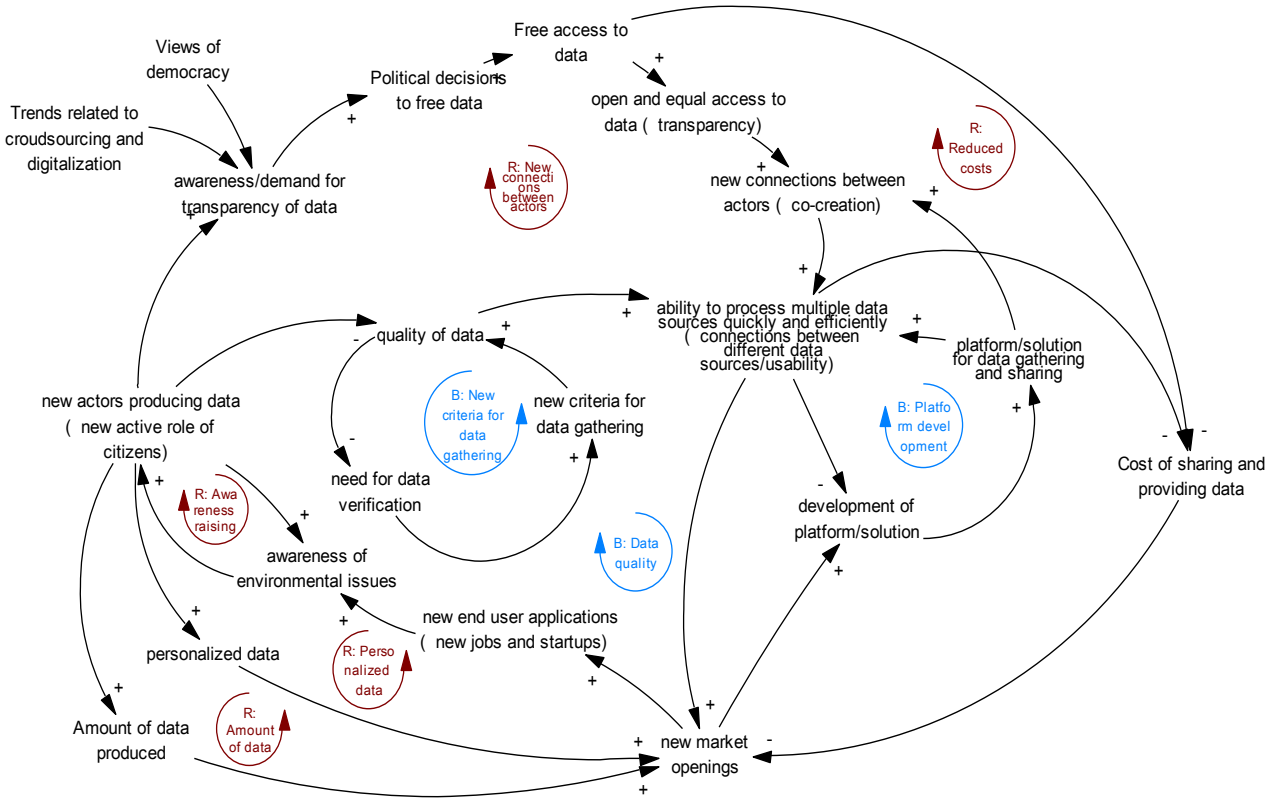
Finally in the world of reputation innovation is analyzed from the perspective of brand and image effect. From a short and long term the aim is in analyzing how the innovation impact to the attractiveness of different actors. The aspects concerning the image and brand needs to be analyzed from the perspective of specific actors and are thus analyzed in details in the following sub-chapter.

To summarize the central findings from the perspective of different type of evaluation criteria following aspects have been recognized. According to our interviews services have important role in renewing the environment sector. To solve the most urgent societal problems, like sustainability, there is need to develop technologies and services as systemic wholes instead of individual technologies or services. The emergence of comprehensive service solutions in renewing the environment and energy technologies can be perceived by traditional measures. However the focus from the perspective of industrial and financial world is on technical characteristics of the concepts and solutions, not so much in their social and systemic nature.

To capture the interactive and social nature of service development as well as its' interlinks to the social goals and system level changes the other criteria are needed. Like our example show, relational and responsible worlds are particularly important to make these aspects visible. Like our respondents highlighted the changing roles of data users and producers ("from user to producer") plays a central role in the renewal and a system level change in a sector. That can be perceived only from the perspective of relational world. In addition our example shows that impacts generated in the different worlds are often interdependent and complementary to each other. Some factors in relational and responsible worlds can be seen as a prerequisite to effects generated from the viewpoint of technical and financial worlds. For example for the development of environmental data platform the transparency and open access to public sector data is seen as a precondition. However, the dynamic nature and interlinkages between different justification criteria are not comprehensible for readers because the analytical table remains. It does not show how the different impact criteria are mutually interlinked and may reinforce or contradict each other. This perspective in our framework is considered in the analysis carried out with the system dynamic modelling tools.

From the systems perspective (Figure 2) free access to data increases open and equal access to data, which creates new connections between actors. This in turn increases the ability to process multiple data sources quickly and efficiently and creates new market openings and new end user applications. An increased number of end user applications increases people's awareness of environmental issues, due to which new actors start producing data. These new actors then create more demand for transparency of data and political pressure to provide even more access to data. (Reinforcing feedback R1 "new connections between actors"). Increasing free access to data also leads to new market openings because of the reduced costs of sharing and providing data (reinforcing feedback R2 "reduced costs").

Figure 2. Systems perspective to environmental data platform



As already noted, an increased awareness of environmental issues leads to citizens becoming active in producing data. This raises awareness even more (reinforcing feedback R3 “awareness raising”). An increased number of new actors producing data also leads to more data and personalized data being produced, which can lead to new market openings (reinforcing feedbacks R4 and R5: “amount of data” and “personalized data”).

There are also balancing feedback loops in the system. Once the number of actors producing data grows, data quality may become an issue and can decrease the ability to process multiple data sources efficiently (balancing feedback B1 “data quality”). However, a low data quality that creates a need for data verification can lead to new criteria for data gathering, which then improves the quality of data (balancing feedback B2: “new criteria for data gathering”). The development of an environmental data platform can also be started in order to improve the ability to process multiple data sources (balancing feedback B3 “platform development”).

5. Concluding remarks

The purpose of this paper is to study the challenge of the evaluation in the context of the services. Because of their specific nature – especially immaterial and interactive dimension – the traditional evaluation methods and measures are not able to capture neither the diversity of the innovations nor the dynamic nature and multifaceted dimensions of performance in the sector. This paper aims to contribute to the need for a more diverse and dynamic evaluation approach. We focus on the context of service innovation in the area of environmental measurement in which we develop further multi-criteria and system dynamic perspectives. Multi-criteria framework describes the impacts of new sustainable services and system perspective analyses dynamic impacts of service innovation.

As a result we identified that services have an important role in renewing the services in environmental measurement. To solve the most urgent societal problems, like sustainability, there is need to develop technologies and services as systemic wholes instead of individual technologies or services. Furthermore the collaborative interaction between societal fields and multiple actors (including citizens) is extremely important.

The emergence of new technologies and new solutions in environmental measurement can be perceived with traditional measures. However the focus from the perspective of industrial and financial world is in technical characteristics of the concepts and solutions. From this traditional perspective neither the role of new solutions in renewing sector (social and value based aspects) nor the importance of interactivity in developing new solutions ca be captured. To perceive and make visible the societal goals of the new solutions as well as their interactive nature relational and responsible worlds are particularly important. In addition relational world also focuses for example to the changing role of end users (“from user to producer”). That can be seen as an enabling factor for the systemic change in the sector and thus a central goal in renewing the sector.

Our analysis also shows that impacts generated in the different worlds are often interdependent and complementary to each other. Some factors in relational and responsible worlds can be seen as a prerequisite to effects generated from the viewpoint of technical and financial worlds. For example cornerstone and reinforcing feedback in developing new service innovations for environmental measurement relates to the free access of data (the perspective of market world). To attain it political decisions to open of public sector data sources (perspective of responsible world) are required. That development facilitates the equal access to the data for multiple types of actors and thus enhances the creation of new connections and provides the new type of collaboration between actors (relational world). This development supports the emergence of new market opening and the development of new end user applications. Like example shows, the relational and responsible aspects are needed to generate long-term technological and economic impacts.

The complex dynamics, interrelationships and multiple feedbacks between the different impact criteria remain invisible without systemic perspective. By integrating multi-criteria and system dynamic perspectives we aim to offer a dynamic alternative to create understanding of development and impacts of service solutions.

Regarding to the further studies more studies would be useful to test the generalizability of our results. Furthermore to go deeper to the dynamic relations studying the role (and impacts) of different actors in service ecosystem could be the next step. In addition generating indicators based on these findings would be both interesting and useful.

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