EVALUATING OPEN DATA INNOVATION: A MEASUREMENT MODEL FOR DIGITAL INNOVATION CONTESTS

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Abstract

Digital innovation contests emerge as important intermediaries in open data markets. However the understanding of how contests affect innovation value chains is low and there is a lack of innovation measurement frameworks to support the management of digital innovation contests. Therefore, in this paper we apply design science to design a measurement model for digital innovation contests from the organizer's perspective that adds to the available knowledge of innovation measurement. We use a recent case of digital innovation contests to motivate the model and discuss its implications on the innovation value chain. The measurement model contributes with new knowledge in the area of open data innovation and provides support for practice in managing innovation through digital innovation contests. For future research we intend to enhance the model to also measure the effects on innovation ecosystems, to operationalize the measures and to evaluate the model in several digital innovation contests as well as to include the perspective of the participants.

Keywords: Innovation, open data innovation, digital innovation contest, innovation measurement, digital service.

1 INTRODUCTION

Innovation is not a new phenomenon (Fagerberg et al. 2006), and new forms of innovation emerge continuously. Innovation has evolved from closed to open (Chesbrough 2003) and now to ecosystems of innovation (Curley and Salmelin 2013; Lindgren et al. 2015). The introduction of information and communication technology (ICT) and the growth of the service sector have resulted in a shift of people to knowledge intensive areas that support innovation (Chesbrough and Spohrer 2006).

Through open architectures (Marton et al. 2013) and the application of infomediary business models (Janssen and Zuiderwijk 2014), open data services can be developed to create societal and business value (Lindman et al. 2013). For example, the European Commission estimates that the outcome of the manipulation and management of open data will enhance the EU economy with as much as €40 billion each year (European Commission 2011).

Open data service development involves third party developers driven by commercial (Ceccagnoli et al. 2012) or non-commercial motives (Kuk and Davies 2011) but also intermediary types of actors such as digital innovation contests (Juell-Skielse et al. 2014). The latter help to strengthen innovation ecosystems and facilitate the establishment of open data markets (Lindman et al. 2013). Digital innovation contests are defined as events "in which third-party developers compete to design and implement the most firm and satisfying digital service prototype, for a specific purpose, based on open data." (Hjalmarsson and Rudmark 2012, p. 10). But open data service development has so far failed to meet the expectations and recent research indicates that only a few of the solutions developed during these events are transformed into open data services that actually reach the market due to innovation barriers faced by participants (Hjalmarsson et al. 2014). In order to strengthen open data innovation and the effects of digital innovation contests, the Innovation Value Chain (Hansen and Birkinshaw 2007) for open digital services need to be better managed. This requires effective management tools, including measurement frameworks for digital innovation contests.

The innovation measurement frameworks found in literature have been developed primarily for measuring the innovativeness of nations, industries or firms. Few of these frameworks have been developed for the purpose of measuring innovation in the context of contests, and they do not take into account how contests affect the innovation value chain. Taking into account the role of organizers in planning and conducting innovation contests to stimulate the generation of new service ideas as well as their exploitation, we argue that there is a need for a specialized innovation measurement model with the purpose to aid in measuring and managing innovation contests. Such a framework can support a more detailed understanding of how innovation contests affect the innovation value chain and innovation ecosystem. Thereby, they can supplement global frameworks measuring innovation in, for example, industries and nations. Bielkowicz et al. (2002) argue that detailed frameworks can contribute with a crosscheck to more global frameworks.

The aim of this paper is to design and motivate a measurement model for digital innovation contests. The paper contributes a novel model adding a new perspective to innovation measurement as well as a modified innovation value chain in view of innovation contests from the organizer's perspective. This adds to the knowledge of innovation and hence improves our understanding for how innovation is managed. Moreover, it helps practice to organize digital innovation contests that meet the organizers' goals and generate anticipated effects. The model has been developed using a design science approach and is based on literature studies as well as a case study of a large digital innovation contest.

This paper is organized in five sections. In the following section we present theory related to innovation contests and innovation measurement. Chapter three includes the method and chapter four the resulting model. In chapter five we discuss the results and in chapter six we draw conclusions and suggest future research based on the results of this study.

2 DIGITAL INNOVATION CONTESTS AND MEASUREMENT

The world of today involves the design and use of novel digital technologies, which penetrate deeply into our society through new products and services. The fundamental features of digital technology are that it enables re-programmability and data homogenization, which create environments characterised by openness and flexibility (Yoo et al. 2012). Yoo et al. (2012) analysis of such environments reveals three traits for digital innovation: 1) the importance of *digital technology platforms* acting as building blocks for innovation (Gawer 2009), providing open resources (Ceccagnoli et al. 2012) enabling 2) *distributed innovations* in terms of harnessing creativity outside the boundaries of an organization (Boudreau et al. 2011) and 3) the frequency of *combinatorial innovation*, that is the creation of new products by merging existing digital artefacts to new and combining existing non-digital artefacts with digital capabilities (Yoo et al. 2012).

2.1 Contests as method to stimulate and structure open data innovation

Contests have become popular to propel distributed digital innovation that harness creativity beyond organizational boundaries and generate digital services based on open data (Hjalmarsson et al. 2014). In general contests are used during early stages of innovation to stimulate the creation of ideas (Bullinger and Moeslein 2010) and service prototypes (Osimo et al. 2012), but also to engage external resources and to ensure that the results are aligned with organizational goals (Hjalmarsson and Rudmark 2012). Different types of contest formats have emerged for distributed innovation: idea competition (Piller and Walcher 2006), community based innovation (Füller et al. 2006), online innovation contests (Bullinger and Moeslein 2010), and digital innovation contests (Hjalmarsson and Rudmark 2012). Bullinger and Moeslein (2010), Hjalmarsson and Rudmark (2012) and Juell-Skielse et al. (2014) present design elements, such as contest purpose and post-contest support, to be used to systematically setup contests that enables distributed innovation.

Juell-Skielse et al. (2014) address design issues in relation to the post-contest domain. They argue that an important decision is to mindfully decide what level of engagement that the organizer should have after the contest to stimulate that results from the contest are transformed into products ready for market entry. Hjalmarsson et al. (2014) argue that only a limited number of results from contests successfully reach and break on an end user market. Juell-Skielse et al. (2014) present a classification with five levels of support to be used by the contest organizer to position its involvement after the contest phase. At the lowest level the organizer provides no support after the contest, letting the third-party developers continue their distributed innovation process on their own. At the second lowest level the third-party developer is provided information and contacts (e.g. to mobilize financial resources) that supports the developer to continue the distributed innovation process independently without any other involvements by the organizer. The third level of support entails that the organizer actively offer support to the winner, i.e. to jointly apply for funding to setup an alliance to co-complete the contest submission. From this third level and above the modus of the organizer is changed from a passive beholder of the distributed process to an active participant in the implementation and exploitation of the service.

At the fourth level, the organizer offers the winning team internal development support. This involvement means that the intellectual rights to the winning results either could stay with the original developer, or be transferred to the organizer. If the winner keeps the rights of ownership then the development support may at this level consist of 1) enrolment in a mentorship program, or 2) support with refining the product through commercial collaboration. On the other hand, if the ownership is transferred to the organizer then this organization may choose to further develop the product without the involvement of the original contestant. This means that the distributed innovation process, spearheaded by the third-party developer, cease to exist and that the continued innovation is incorporated in the organizers own internal innovation process. The fifth and final level of support means that the organizer and the winner merge into one entity with the purpose to complete the product. At this level the organizer provides comprehensive support related to marketing, sales and public offerings associated with exploiting the outcome and integrate it as module in its repertoire of

products. Also in this situation the distributed innovation process absorb into the organizers internal innovation process (Juell-Skielse et al. 2014).

2.2 Measuring Innovation

There are several models and frameworks available for measuring innovation, which vary in terms of purpose and scope. For example, there are models for evaluating innovation at nation, industry and firm level (Mairesse and Mohnen 2002), and there are models for product, process, and organizational and marketing innovation (OECD 2005). Measuring innovation can be done to assess the contribution and effectiveness of an organization in an ecosystem where it operates. For example, Porter's diamond model enables evaluation of the ability of organizations to succeed within a nation Porter (1990). There are also innovation measurement frameworks for evaluating characteristics of innovation processes, for example, the openness of innovation (Enkel et al. 2011). Several models are based on the Innovation Value Chain (IVC) to identify weak links in the sequence of activities supporting innovation (Hansen and Birkinshaw 2007; Ress et al. 2013). Several models also borrow elements from the Balanced Scorecard (Kaplan and Norton 1996) and present Key Performance Indicators to measure innovation (Erkens et al. 2013; Ishak et al. 2014; Ishak et al. 2013; Hansen and Birkinshaw 2007) or complete scorecards for measuring innovation, e.g. to measure open innovation in university and industry collaborations (Flores et al. 2009). In Table 1, we present a selection of measurement models and frameworks found in literature. In the table, we delimit ourselves to firm level models and exclude nation and industry level models.

Few of these frameworks have been developed for the purpose of measuring innovation in the context of contests. The framework presented by Washizaki et al. (2007) is developed for measuring quality of embedded robot software in design contests with a focus on the artefacts and does not cover the whole IVC including implementation and exploitation. Taking into account the role of organizers in planning and conducting innovation contests to stimulate new service ideas and then the different levels of involvement of organizers in implementing and exploiting the outcomes of innovation contests we argue that there is a need for an additional framework with the purpose to aid in measuring innovation contests. Innovation contests affect the IVC and hence how innovation is monitored and measured. The assessment made possible through the use of such a framework can help in a more detailed understanding of how innovations stimulated by innovation contests affect the whole innovation system and provide a crosscheck (Bielkowicz et al. 2002) and supplement global frameworks measuring innovation in, for example, industries and nations.

Name of model and framework	**Type**	**Main components**	**Measurement**
Diamond (Tidd et al. 2002; Gamal et al. 2011)	Organi-zational	**Dimension for innovation assessment** Strategy, Process, Organization, Linkages, Learning	Set of questions to assess these dimensions with values 1 to 7
Diamond of National Advantage (Porter 1990)	NA	**Determinants of competitive advantage** Factor conditions, Demand conditions, Related and supporting industries, and (Firm Strategy, Structure, and Rivalry)	Operationalization suggested by for example Bakan and Dogan (2012)
Frameworks in Measuring Innovation: Initial Approach (Rose et al. 2009)	Organi-zational	**Framework 1(F1): Measuring Innovation Activity**– human capital, intellectual capital, organizational capital **Framework (F2): Measuring Investments -** Human capital, technical knowledge, and ICT infrastructure	**F1**-Training, experience, R&D, databases, ICT infrastructure, etc. **F2**-Training, experience, education, scientific R&D, R&D in social sciences and humanities, etc.

Innovation Capability Maturity Model (Essman and Du Preez 2009)	Organi-zational	**Dimensional frameworks** Innovation capability construct, Organizational construct and Capability maturity	Five levels of maturity of Under Capability maturity (Level 1-5) for
Innovation Funnel (Morris 2008; Gamal et al. 2011)	Process	**Phases of innovation** Input (Strategic thinking, portfolio management), Process (Research, Ideation, Insight, Targeting, Innovation Development, Market Development), Output (Sales)	Qualitative metrics with proactive questions and Quantities metrics, specific metrics of each type is listed in Morris (2008)
Innovation in Biopharmaceutical Firms (Michelino et al. 2014)	Marketing	**Components in financial and economic transactions** Inbound processes and Outbound processes	Ratios of cost, revenue, additions, disposal and openness. Openness ratio is derived from the above
Innovation Production Process (IPP) (Guan and Chen 2010)	Process Marketing	**Components** R&D (Stage1) and Commercialization (Stage 2)	**Quantitatively measure** R&D efficiency and Commercial efficiency
Innovation Value Chain (Hansen and Birkinshaw 2007)	Process	**Phases of innovation** Idea generation, Conversion, Diffusion	**Key Performance Indicators** Number of high quality ideas, Percentages of ideas funded & of market penetration, etc.
Innovation Value Chain (Roper et al. 2008)	Process	**Phase of innovation** Knowledge sourcing, Transformation, and Exploitation	**Innovation indicators** Percentage of new products, knowledge sourcing, firm performance, resources, etc.
Open Innovation Maturity Framwork (Enkel et al. 2011)	Organizatio nal	**Elements** Climate for innovation, Partnership capacity, Internal processes	**Maturity levels** (1-5) Initial/Arbitrary, Repeatable, Defined, Managed, Optimizing
Open Innovation Measurement Toolkit (Erkens et al. 2013)	Process	**Phases of innovation** Lead user method, Ideation and Downstream	**Key Performance Indicators** Input, Output, Process and Outcome
Software Measurement Model (Edison et al. 2013)	Process	**Phases of Innovation** Inputs, Activities, Output, Performance, Determinants, and Feedback	Innovation capability, innovation output, and impact of innovation
Software Quality Evaluation Framework (Washizaki et al. 2007)	Product	**Characteristics** Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability	**Evaluations** Validity of content, logical correctness and presentation, whether it is completed or not, course time/rank

Table 1. Measurement models and frameworks

3 METHOD AND CASE DESCRIPTION

The method of the study is based on design science. As suggested by Peffers et al. (2007), there are six activities in a design science study: problem identification, objectives of a solution, design and development, demonstration, evaluation and communication. The work carried out for all of these activities primarily builds on literature studies and a case study, as described in Section 3.1. The focus of this study is on the first three design science activities and we demonstrate the model using a running example. For future research we intend to evaluate the artifact more rigorously.

To review literature we used variants of the following keywords: innovation, innovation measurement, innovation management, open data innovation, digital innovation contest and other keywords related with specific innovation measurement models. We have used Google scholar, ACM, Springer, and DIVA digital libraries to search for relevant articles.

For problem identification, the starting point is the challenge of assessing the effects of innovation contests. This problem is a wicked problem due to the complex nature and limited understanding of innovation systems. Therefore, an exploratory case study is an adequate approach for gaining an improved understanding of the problem.

The objectives for the proposed measurement model have been elicited primarily through a literature study on innovation contests and their goals, but also through an analysis of the case study. Requirements on measurement models for innovation have also been taken into account. The key objectives of the model are the following:

- To aid in measuring the fulfillment of the goals of an innovation contest
- To aid in identifying strengths and weaknesses in the IVC by measuring underlying factors affecting the results of innovation contests
- To support organizers in learning and increasing maturity in open innovation
- To be easy to use by organizers of innovation contests, i.e. based on available data

The focus of the study has been on design and development, and the measurement model is informed by existing measurement models for innovation, see Table 1. The case study has also been used for identifying key characteristics of the activities in an innovation contest. Demonstration has been carried out by applying the measurement model to the case study, as described in Section 4, thereby showing the viability of the model. Empirical evaluation is left for further work, but an evaluation through informed argument is offered in Section 5.

3.1 Case Description

Storstockholms Lokaltrafik (SL) is the public transport company in Stockholm serving 800 000 travelers on a daily basis. Together with Samtrafiken, a company that provides nationwide ticketing and journey planning, owned by Swedish public transport organizations, SL in September 2011 launched Trafiklab.se as an open data hub providing public transport data and open platforms to third party developers. SL and Samtrafiken, with the support of an independent research institute, designed and organized Travelhack 2013 in the fall of 2012, as a contest with a twofold purpose: 1) to increase the usage of the open data platform Trafiklab.se, 2) stimulate third-party developers to pursuit development of novel digital services that make public transportation more attractive in the Stockholm region. The main objective was to stimulate distributed open innovation of digital services that enable smart public transport usage. This objective was divided in four intended effects with the contest phase:

- Five novel digital services, easy to communicate, that enable smart public transport usage.
- 150 participants (20-30 teams) at the final event
- Two services that actively is in development and used one year after the contest
- One service that has reached top ten in most downloaded services in the travel category in Sweden three years after the contest (AppStore/Android Market)

The contest was launched in mid December of 2012 and continued three months, divided into three phases (idea, preparation and final). 217 interested parties signed up after the contest launched in December 2012 and by mid January 58 digital service ideas had been entered targeting one of three contest categories: 1) Digital services that make public transportation trips more fun 2) Digital services that make public transportation more efficient 3) Digital services that make public transportation more accessible to everyone, especially passengers with cognitive disabilities. The ideas were subjected to an evaluation that resulted in that contest organizers, in mid February, invited 25 of the total 58 entries to attend a 24-hour final hackathon in March. The shortlist of finalists was based on innovativeness, potential to make impact, technical feasibility, and usefulness. During the second phase, preparation, the teams were provided additional APIs from both the organizations behind the contest (funneled through Trafiklab.se) and other organizations that had been involved by the organizers with open data resources of relevance to the three contest categories (i.e. Spotify and Microsoft).

During the concluding contest phase, the final 24-hour hackathon, 21 teams finalized their service ideas into prototypes and an expert jury selected the winners. The team behind the digital service

Resledaren[1] won both the category for making public transportation more accessible to everyone and the overall winners' prize. The organizers had no intention to acquire any of the contributions. However, by 1) the defined set of criteria for evaluation and using an expert jury to select winners, they deliberately ruled the outcome with the aim to point out the services with the highest potential to become viable. Furthermore, 2) by offering active support to the winner to jointly apply for funding of a collaborative service innovation project (funded by the Swedish government agency for innovation, Vinnova) create a financial base for the winner to transform the winning submission to a market ready product. The primary motive for the latter was according the organizers to:

"…promote the development, launch and marketing of the winning submission as a viable open data service (Resledaren) that enables people with cognitive dysfunctions to access and use public transportation, and investigate how such collaboration is organized with the aim to develop sustainable capability to recurrent organize cost-effective open digital innovation on large scale." [2]

In the fall of 2013 the consortium with the winning team, SL and Samtrafiken as key stakeholders received funding for the joint project (€ 150,000). And in September 2014 the first version of Resledaren was launched on Google Play and iOS App Store.

4 RESULTS

The measurement model is developed from the perspective of organizers of innovations contests and includes two fundamental processes: the *Innovation Contest Process* and the *Service Deployment Process* see Figure 1. The model is based on the Innovation Value Chain (see for example Ishak et al. 2014; Ishak et al. 2013; Hansen and Birkinshaw 2007) but the phases are adapted to include the use of innovation contests to stimulate ideation and service design. The phases include planning, ideation, service design, implementation and exploitation. The two processes are recursive, resembling the feedback loops described by Edison et al. (2013) and Guan and Chen (2010), which enable learning over time. Innovation propelled by digital innovation contests is an emerging phenomenon and to work effectively it requires time to mature Enkel et al. (2011). However since the involvement of actors is likely to change between innovation contest and service deployment it is reasonable to divide the phases of IVC in two separate processes. Hence an additional preparation phase for the service deployment process is needed.

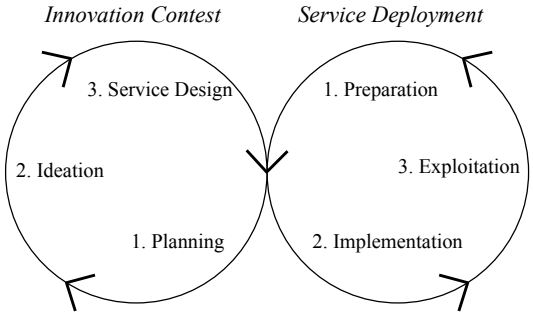

Figure 1. The innovation contest process and the service deployment process.

The *Innovation Contest* process includes three phases: *Planning*, *Ideation* and *Service design*. In the planning phase the innovation contest is designed and marketed with the goal to attract participants with profiles that match the goals of the contest organizers. In the ideation phase organizers support the participants to generate ideas and select the best ideas. In the prototyping phase organizers support the participants to develop service prototypes and select winners. In Travelhack 2013 the contest was divided into an ideation phase from which finalists were selected and a service design phase including only finalists that also got the opportunity to design service prototypes. However the three phases may

[1] http://www.resledaren.se/
[2] VINNOVA dnr. 2013-02158

also be combined into two phases for innovation contests that merge ideation and service design when the participants are asked to present both ideas and service designs on the same time (Juell-Skielse et al. 2014). The *Service Deployment* process also includes three phases: *Preparation*, *Implementation* and *Exploitation*. In the preparation phase the organizers set up goals for service deployment and prepare the organizers' organizations for meeting these goals. The organizers can choose to be involved at different levels (Juell-Skielse et al. 2014) from no involvement at all to full ownership and responsibility for service deployment. In the implementation phase the service is developed to a commercially viable product and in the exploitation phase the service is brought to market.

The two processes are congruent and are connected where selected service prototypes in phase *3. Service Design* of the Innovation Contest Process move to phase *2. Implementation* of the Service Deployment Process. For example the organizers of an innovation contest of digital services for public transportation may choose to invest money in return for equity and provide development skills to the winning team in order to support the deployment of the team's service prototype. From the perspective of the team, the processes may not be viewed as two, the team rather continues implementation after service design ends. But from the perspective of the organizer the contest process is separated from the service deployment process as service deployment requires new decisions regarding goals and the involvement of resources other than the resources involved in organizing the innovation contest.

4.1 Measuring the Innovation Contest Process

The model is informed by the schemes used by Hansen and Birkinshaw (2007) and Erkens et al. (2013) and is described in terms of *Input*, *Activities*, *Output* and *Measures*, see Table 2. *Input* is the resources that the organizers of an innovation contests brings in to the contest. Examples of inputs are open data sources, domain knowledge, time and money. Each phase is divided into *activities* of work that the organizers perform. *Output* is the end result from each of the phases. *Measures* are the metrics used to measure input, activities and output. Measures related to input and activities are viewed as leading indicators while measures related to output are viewed as lagging indicators (Kaplan and Norton, 1996).

Phase	**Planning**	**Ideation**	**Service Design**
Input	Resources, for example API info, open data sources, domain knowledge, financial resources	Time, resources and facilities	Time, resources and facilities
Activities	a. Specify problem – solution space b. Design contest, i.e. applying the design elements, establish evaluation criteria c. Market contest, i.e. events, website, media coverage, make resources available	a. Support in idea generation, e.g. problem descriptions, personas, meet-ups, technical support, business model support b. Select finalists: evaluate ideas and business models	a. Support in service design, e.g. hackathon, technical support, business model support b. Select winners: evaluate prototypes and business models
Output	Registered participants ready to contribute to the competition	High quality digital service ideas	High quality digital service prototypes
Measures	• Available resources • Problem – solution maturity • Contest quality • Visibility • Number of participants	• Available resources • Utilization of available resources • Problem - solution maturity • Quality of support • Time invested by participants • Number of submitted ideas • Ratio of ideas per participant	• Available resources • Utilization of available resources • Problem - solution maturity • Quality of support • Time invested by participants • Number of digital service prototypes • Ratio of prototypes per

		• Number of high quality digital service ideas • Visibility	participant • Number of high quality digital service prototypes • Visibility

Table 2. Measurement model for the Innovation Contest Process.

4.1.1 Planning

The planning phase includes three activities aimed at specifying the problem – solution space and designing and launching an innovation contest that attracts participants with the right profile to develop service ideas and prototypes that will provide innovative solutions to the problem. The organizers provide input in the form of open data sources, application programming interfaces (API), domain knowledge and financial resources for carrying out the event. The output of this phase is participants registered to the contest and ready to contribute to the competition. The lagging indicator is *Number of participants* while *Available resources*, *Problem – solution maturity* and *Contest quality* and *Visibility* are leading indicators.

Problem – solution maturity is an index inspired by Mankins (1995) measuring how defined the problem is and how effective known solutions are to solve the problem: Low – unspecified problem and lack of solutions; Medium – specified problem and lack of solutions; High – specified and acknowledged problem and availability of less effective solutions; Very high – clearly specified and highly acknowledged problem and effective solutions available on the market. Contest quality measures how well the contest design fulfils the goals of the contest. Visibility is a compound measure based on indicators such as number of visitors to website, number of newspaper hits and number of participants in meetings.

4.1.2 Planning Phase Running Example

The organizers of Travelhack 2013 began the preparation of the contest in the fall of 2012. At that time the *problem–solution maturity* can be defined as medium. Two of the contest challenge categories were based on problem areas well understood by the organizers: 1) current users of public transportation (PT) lack efficient tools to effectively utilize PT, 2) non-users of PT lack knowledge about the value with PT. The aim with the last contest category was to increase the problem-solution maturity regarding people with disabilities. Relative all categories, the solution maturity was low. After the launch in January 2013, the organizers, on a daily basis, monitored the number of participants visiting the contest website as well as the number of teams signing up. They understood that the contests capability to harness distributed creativity was mirrored through the number of potential participants showing an interest to the contest, and they actively used this monitoring to adjust their preparation in terms of marketing efforts. *Visibility* in media - especially the contest level of penetration through social media - was systematically measured and used as base for marketing decisions; e.g. procurement of Facebook marketing. The *contest quality* was at this stage evaluated through the benchmarking of the design using two focus groups with third-party developers and prominent members from the open data community. To understand the *quality of support* the organizers made a structured survey of the participants' support needs later on during the process.

4.1.3 Ideation

The ideation phase includes two activities aimed at generating high quality digital service ideas: Support in idea generation and Select finalists. The support in idea generation can take different forms such as problem descriptions, personas, meet-ups and technical support and business model support. Personas are fictional characters that represent user types as a basis for design (Lidwell et al. 2010). Finalists can be selected through various means such as jury evaluations and peer reviews or a combination. The organizers provide input in the form of time, facilities and financial resources. The output of this phase is high quality digital service ideas. The result indicator is *Number of high quality digital service ideas* while *Available resources*, *Problem - solution maturity*, *Quality of support*, *Time invested by participants*, and *Number of submitted ideas* and *Ratio of ideas per participant* are leading

indicators. Quality of support is a compound measure evaluating support activities in terms of use and satisfaction.

4.1.4 Ideation Phase Running Example

The ideation phase was closed on February 5 2013. The number of registered teams at this stage were 213 (*number of ideas*), of these 54 had submitted high quality digital service ideas to a ratio of one idea per team (*ratio of ideas per team* and *number of quality ideas*), that matched the organizers intent with the three challenge categories. From this set of ideas a jury utilizing five *defined evaluation criteria* selected 24 finalists who were invited to pursuit their distributed service design for one month with the aim to transform their idea to a working digital prototype. During this phase the organizers through the contest webpage and trafiklab.se provided team resources such as information about the public transportation network, open data and toolboxes to promote end-user design (*available resources*). These resources were partly provided based on requests harvested from the survey, partly based on the evaluation of the submissions done by the organizers illuminating what the teams needed in order to elevate their ideas to prototypes (*quality of support*). In order to ensure that the final development would take place on the final event some of the open data resources were only advertised to the teams, however not released until the final. The organizers also continued to measure the *visibility* and impact of the contest in different media channels. For example, by monitoring the contest impact on social media sites and blogs. In order to further boost the visibility of the contest, the organizers made a traditional press release to national and local daily newspapers.

4.1.5 Service Design

The service design phase includes two activities to generate high quality digital service prototypes: Support in service design and Select winners. The support for service design can take different forms such as hackathons, technical support in using open data and support in developing attractive business models. Winners can be selected through various means such as jury evaluations and peer reviews or a combination. The output of this phase is digital service prototypes of high quality and the lagging indicator is *Number of high quality digital service prototypes*. The leading indicators are *Available resources*, *Problem - solution maturity*, *Quality of support*, *Time invested by participants*, and *Number of digital service prototypes*, *Ratio of prototypes per participant* and *Visibility*.

4.1.6 Service Design Phase Running Example

Travelhack 2013 ended in March 2013 with a final 24-hour Hackathon. Of the invited finalist teams, 21 teams eventually attended. An expert jury with members from the transport domain, service developers, disability experts and leading members of the open data service community evaluated and rated the prototypes using a defined set of criteria. The jury members interviewed the teams twice during the final and got pitch presentations from the teams for their judging. During the final the teams also received on-site and online support from the open data providers advocated by organizers. The participants were not restricted to use these open data sources, however the open data was selected to provide the teams suitable sources for their designs. The post-contest evaluation indicates that the developers appreciated the organized support especially that it was available during the whole contest. This support design was created based on from the survey done prior to the implementation phase. During the contest one of the APIs malfunctioned, this was however resolved within 30 minutes due to the API-support standing by. In all 79 developers in the teams invested 1896 hours finalizing the 21 prototypes during the final event. Each prototype addressed the problem areas that the contest focused elevating the organizers' problem–solution maturity from medium to high/very high. The contest also boosted the number of registered users on www.trafiklab.se from 750 to more than 2500.

4.2 Measuring the Service Deployment Process

The *Service Deployment* process is also described in terms of *Input*, *Activities*, *Output* and *Measures* see Table 3.

Phase	Preparation	Implementation	Exploitation
Input	Resources, such as open data, knowledge, relationships, time and money.	Time and resources depending on level of post-contest support	Time and resources depending on level of post-contest support
Activities	a. Decide level of post-contest support b. Establish goals for service deployment c. Organize resources based on goals (in a) d. Go/No go decision	a. Support service implementation at various levels (from no support to very high support) b. Evaluate service quality c. Evaluate market potential d. Go/No go decision	a. Support service delivery at various levels (from no support to very high support) b. Support service commercialization at various levels (from no support to very high support) c. Continuous evaluation of service quality and market potential
Output	Prepared organization	Viable digital service, business model and intellectual property	Service revenue
Measures	• Level of post-contest support • Available resources • Level of commitment	• Available resources • Quality of support • Problem – solution maturity • Service demand	• Available resources • Quality of support • Problem – solution maturity • Service usage • Rate of diffusion • Number of downloads • Revenues

Table 3. Measurement model for the Service Deployment Process.

4.2.1 Preparation

The aim of this phase is to prepare the organization for service deployment. The organizers' of an innovation contests' can choose to be involved in service deployment at different levels (Juell-Skielse et al. 2014). Given these levels of involvement the organization must formulate goals for its involvement and to organize resources to fulfill these goals and decide whether to proceed to the next phase or not. The output from this phase is an organization prepared for supporting service deployment. The lagging indicator is *Level of commitment* and leading indicators are *Level of Post-Contest Support*, *Available resources and Level of Commitment*. Level of commitment is a compound measure consisting of indicators for organizers' level of commitment such as top management support, degree of involvement and team's level of commitment to implement their service.

4.2.2 Preparation Phase Running Example

To promote that the winning prototype was transformed into a market ready product the organizers decided to offer the winning team active support to apply for external development and competence funding (*degree of involvement*) from the National Agency for Innovation in Sweden (Vinnova). The offer was preceded by a joint decision on *top management* level to facilitate a situation wherein the team could re-activate development post-contest with the objective to complete the digital prototype ready for market entry within two years of the contest. The degree of involvement can be defined as medium using the Juell-Skielse et al. (2014) classification of support level. In this case this meant that the winning team retained the intellectual property of the solution developed and performed the majority of development. The organizers provided complementary support i.e. to apply for third party funding and would in later phases provide market information, support to use data sources, capacity to perform business model design and market communication support. The winning team accepted the offer from the organizers and transformed itself to a limited company and thus enabled the creation of a consortium to jointly with the organizers' apply for third party funding in May 2013.

4.2.3 Implementation

In this phase the aim is to ramp up development of the prototype into a viable digital service and prepare market entry. It consists of three activities: Support service implementation, Evaluate service

quality and Evaluate market potential and Go/No go decision. The level of support for service implementation depends on the goals established in the preparation phase as well as the level of commitment. The output of this phase is a viable digital service with a compelling business model and associated intellectual property. The lagging indicators are *Problem – solution maturity* and *Service demand*. Service demand is measured through focus groups and user test panels. The leading indicators are *Available resources* and *Quality of support*.

4.2.4 Implementation Phase Running Example

In fall of 2013 Vinnova awarded the consortium €150,000 to transform the winning prototype to a viable digital service launched to the public within one year from the funding decision. Development work was organized as a project with five inter-related work packages. It began in October 2013 and ended in January 2015. During that time the organizers provided *available resources* to the development effort in different ways within the support scope defined. *Service demand* was measured through the involvement of end users throughout the design phase and by user test panels during the pilot test phase. These evaluation efforts provided input to increase the organizers *problem-solution maturity* regarding knowledge about how travellers with cognitive dysfunctions use PT. By in-depth evaluation of the process the organizers' also increased their knowledge about constraints affecting post-contest service implementation, which increased the organizers' problem-solution maturity regarding organising distributed digital innovation based on open resources, e.g. open data.

4.2.5 Exploitation

This phase aims at creating revenues from the use of the digital service. It includes three activities: Support service delivery, Support service commercialization and Continuous evaluation of service quality and market potential. Again the level of support depends on the goals established in the preparation phase. The output of this phase is service revenues and the lagging indicator is *Service Revenue*. The leading indicators are *Available resources*, *Quality of support*, *Problem – solution maturity*, *Service usage*, and *Rate of diffusion* and *Number of downloads*.

4.2.6 Exploitation Phase Running Example

In September 2014 the winning team, now operating as a limited company, entered the public market by releasing the first version of Resledaren on Android Store and iOS app store. As the organizers had decided to limit their level of support to the implementation phase and only provide support in applying funding, data set usage, business model design and evaluation this case does not cover the exploitation phase described in the measurement model depicted in Table 3.

5 DISCUSSION

The proposed measurement model adds to the available models and frameworks for measuring innovation. Our contribution is the inclusion of digital innovation contests and by developing the model from the perspective of the organizer of innovation contests. It satisfies the key objectives as stated in section 3: the model is capable of measuring all the contest goals described in the case study Travelhack13, it aids in identifying strengths and weaknesses in an innovation contest by measuring the activities performed in each of the phases of the innovation value chain, due to its recursive design it supports organizers in learning from one event to another, the suggested measures are based on data easily attainable by organizers of innovation contests as illustrated by the running example.

The measurement model is based on a modified innovation value chain that supports organizers of digital innovation contests to understand how to manage innovation from planning to exploitation of digital services. The modified innovation value chain takes a holistic view on service innovation and includes input, process, outcome and measures. It is divided into two congruent processes due to the change of requirements on the organizers after the contest is finished and before service deployment can start. Organizers must prepare new goals and reorganize their resources for the second process.

The problem solution maturity index will help organizers of digital innovation contests to both formulate problems and to evaluate ideas and solutions. The problem solution maturity is related to technology readiness indexes (Mankins 1995) and maturity levels found in innovation measurement models or frameworks (Essman and Du Preez 2009; Enkel et al. 2011).

The proposed measurement model is designed from the perspective of organizers of innovation contests and does not fully support in measuring the specific effects on the innovation system in which the innovation contest is organized. It can be used to provide details about new entrants into an innovation system but does not provide support for measuring new relations between actors of an innovation system.

In this study, we use a running example to demonstrate the model, thereby showing its feasibility. However, the study is still limited in terms of evaluation, and there is, therefore, a need for further research to improve the evaluation of the model.

6 CONCLUSION AND FUTURE RESEARCH

The aim of this paper is to add to the measurement of innovation and specifically open data innovation and the use of digital innovation contests. We present a measurement model based on an innovation value chain from the perspective of organizers of digital innovation contests. We conclude that the measurement model contributes with new knowledge in the area of open data innovation and provides support for practice in managing innovation through digital innovation contests. It increases the knowledge about how digital innovation contests affect the Innovation Value Chain from the perspective of organizers of digital innovation contests and provides a detailed cross-check for more general models. To practice it provides better means for setting up and monitoring innovation contests to manage the output and meet the goals of the contests. Moreover the measurement model, due to its recursive nature, enables practice to learn over time.

For future research we intend to enhance the model to also measure the effects on innovation ecosystems, to operationalize the measures and to evaluate the model in several digital innovation contests as well as to include the perspective of the participants.

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