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Unveiling DRD: A Method for Designing and Refining Digital Innovation Contest Measurement Models

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Abstract

The growing open data market opens possibilities for the development of viable digital artifacts that facilitate the creation of social and business values. Contests are becoming popular means to facilitate the development of digital artifacts utilizing open data. The increasing popularity of contests gives rise to a need for measuring contest performance. However, the available measurement model for digital innovation contests, the DICM-model, was designed based on a single case study and there is a need for a methodological approach that can accommodate for contests' variations in scope. Therefore, we use design science to construct a nine-step method, the DRD-method, to design and refine DICM-models. The DRD-method is designed using goal- and quality oriented approaches. It extends innovation measurement to the application domain of digital innovation contests and provides an improvement of innovation measurement as it offers a new solution for a known problem. The DRD-method provides comprehensive support to practice for designing and refining DICM-models and supports reflection and organizational learning across several contests. For future study, we suggest an ex-post evaluation of the method in conjunction with real contests and systematic efforts to generalize the method within as well as beyond the context of the contest. Finally, we propose to further investigate the potential of top-down and goal oriented approaches to measure open and iterative forms of innovation.

Keywords: Digital Innovation Contest, Design of Measurement Model, Open Data Innovation, Goal Oriented Measures, Goal Question Metric

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1 Introduction

Digital innovation is the activities, more or less structured, in which a new product, process, or business model emerge based on information technology adoption (Fichman et al. 2014). Digital innovation can originate from technological advancement; e.g., the Internet of Things (IoT) enabling the utilization of digital artifacts combined with well-established solutions (Atzori et al. 2010). Moreover, pervasive digital artifacts are increasingly penetrating and altering the nature of product and service innovations in organizations (Yoo et al. 2012). Similarly, digital innovation may be initiated by the growing availability of open data, which creates opportunities for innovation in both public and private sectors (Zuiderwijk et al. 2014). The growth of open data is exponential and its direct market, only in EU, is estimated to grow by 36.9% between 2016 and 2020 (Kundra 2012; Carrara et al., 2015). There are plenty of open data for the public to advance entrepreneurship, stimulate start-ups, and enhance services (Lakomaa and Kallberg 2013). Access to open data also facilitates social and business value creation (Lindman et al. 2013) and is in turn enabled by innovation and openness (Jetzek et al. 2013). However, open data has no value unless utilized, and yet little is known about the development of digital service from open data (Janssen et al. 2012).

Digital innovation contest has evolved into a mechanism to stimulate service development based on open data and other provided resources (Juell-Skielse et al. 2014; Smith et al. 2016). Viewed as an approach, a digital innovation contest supports organizers to manage the fuzzy practice that characterizes early stage innovation when it involves multiple actors (Hjalmarsson and Rudmark 2012; Hjalmarsson et al. 2017).

One important activity in the management of any innovation process is measurement. Still, it is not as easy to measure or evaluate innovation as it is to measure revenue improvement (Malinoski and Perry 2011). This is even more the case in an evolving new context as digital innovation based on open data, organized as a contest. A digital innovation contest is an investment of time and resources from participants as well as resources providers (Hjalmarsson and Rudmark 2012). It is used as a mechanism to push external developers to create a solution that is of value for beneficiaries. To assess if the investment added value and if the results from the contest adhered to the organizational goals stated, systematic evaluation is needed to monitor contest progress and output (Hjalmarsson et al. 2017). A systematic review of literature indicates that few existing evaluation models are appropriate in the task to assess open data development using digital innovation contest as approach. Instead, Ayele et al. (2015) propose a context specific model, the Digital Innovation Contest Measurement Model (DICM-model), to evaluate digital innovation organized as contest from beginning to end. However, the DICM-model in its early version failed to fully enable adaptable assessment; i.e. as conditions differ for contests, the DICM-model needs to be adapted and customized for the situation at hand (Ayele et al. 2015); a capability that the original model did not include due to being the product of a single case study. Therefore, in this paper, we address the following research question:

- How can we create a method for designing and refining measurement models for digital innovation contests?

To address the research question, a method to design and adapt DICM-models is proposed as a result of systematic design science research. The method, called Design and Refine DICM-models (DRD-method), facilitates the process to tailor DICM-models to adhere to contest conditions and specifically the goals that the innovation contest aims to achieve. Thereby, the method supports contest organizers and innovation managers in building DICM-models that are well adapted for the specific contest conditions. This in turn ensures that a contest organizer and other involved stakeholders (e.g. beneficiaries and resource providers) can monitor the impact of contest driven digital innovation with high degree of rigor from beginning to end.

This paper has seven sections. In the next section, we present theoretical foundations of innovation measurement and innovation contests. The third section outlines the method followed by its design and presentation in Section four. In Section five, the evaluation of the method is presented, and Section six contains a discussion about the value and contribution of the method. Finally, we conclude the paper and discuss future research in Section seven.

2 Theoretical foundation

In this section, we introduce innovation measurement and present how the DICM-model is designed to measure digital innovation contests. Then we discuss Goal Question Metric, Balanced Scorecard and Quality Improvement Paradigm models as a theoretical foundation for developing a method for designing and adapting models for measuring digital innovation contests.

2.1 Digital Innovation Contest Measurement Model

The innovation measurement frameworks found in literature have been developed primarily for measuring the innovativeness of nations, industries and firms (c.f. Mairesse and Mohnen 2002; Porter 1990; Enkel et al. 2011; Hansen and Birkinshaw 2007; Ress et al. 2013; Erkens et al. 2013; Ishak et al. 2014; Ishak et al. 2013; Flores et al. 2009). Several of these frameworks are built on the notion that innovation is carried out in a sequence of phases, the so-called Innovation Value Chain (Hansen and Birkinshaw 2007). Few of these frameworks were developed for measuring innovation in the context of contests, and they do not consider how contests affect the Innovation Value Chain (Ayele et al, 2015).

Due to the lack of measurement models for digital innovation contests, Ayele et al. (2015) proposed the Digital Innovation Contest Measurement Model (DICM-model). Its design is informed by the Innovation Value Chain (IVC) presented by Erkens et al. (2013) which includes inputs, activities, outputs, and measures for each phase of the innovation value chain.

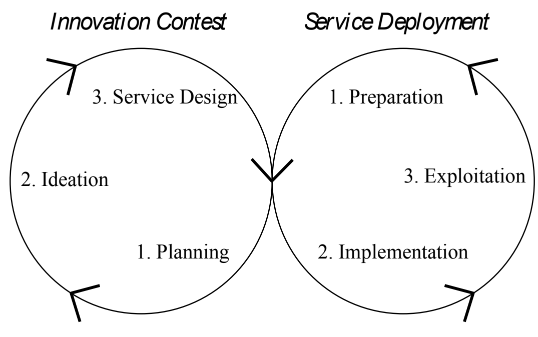


Figure 1: The innovation contest process and the service deployment process of the DICM-model (Ayele et al., 2015, p. 7).

The DICM-model enables the evaluation of digital innovation contests using open resources, e.g. open data, (Ayele et al. 2015). It covers the Innovation Contest process and the succeeding Service Deployment process with three phases each, see Figure 1. The Innovation Contest Process includes the phases: planning, ideation, and service design. The Service Deployment Process covers the phases: preparation, implementation and exploitation, i.e. to convert software prototypes to viable digital services and evaluate their diffusion (Ayele et al. 2015). Each phase consists of inputs, activities to convert inputs to outputs, outputs, and measures to evaluate leading and lagging indicators. A summary of the DICM-model is presented in Table 1.

Table 1: Summarized components of the two processes of the DICM-model.

	Innovation Contest Process			**Service Deployment Process**		
Phases	Planning,	Ideation	Service Design	Preparation	Implementation	Exploitation
Inputs	Inputs are resources that organizers of contest bring in to the contest					
Activities	Activities of work that contest organizers perform					
Outputs	The end result from each phase					
Measures	Measures related with leading and lagging indicators					

When first presented, the DICM-model was anchored only in a literature review and a single case study. Since digital innovation contests are organized by a variety of organizations in different domains (c.f. Carvalho 2009; Bullinger and Moeslein 2010; Hjalmarsson et al. 2017), there was uncertainty whether the DICM-model adequately supported differences in contest goals and was sufficiently flexible to adapt to different contexts. The situation is similar to measuring software development in general, as software development is the core competence used by the participants of a digital innovation contest (Hjalmarsson and Rudmark 2012). Measurement of software development is preferably done in a top-down fashion, due to the large variety of available metrics (Basili 1992). By tailoring measurement models to the goals of a software development initiative, the measurement models will be adapted to the context of the initiative.

There are several approaches for developing measurement models in the literature. Basili (1992) suggests the adoption of the Goal Question Metric (GQM) paradigm to design measurement models for software development, since it provides a systematic approach for defining and evaluating a set of goals using measurement. In addition to the GQM paradigm, the Balanced Scorecard (BSC) and the Quality Improvement Paradigm (QIP) represent approaches for developing organizational measurement models. Like GQM, these two approaches define contextually dependent goals top-down and develop metrics to evaluate the organizational performance in relation to these goals. Hence, all three approaches provide a promising starting point for designing a method for measuring digital innovation contests.

2.2 Goal Question Metric

The Goal Question Metric approach (GQM) uses goals to define measures for innovation (Misra et al. 2005). The GQM was originally introduced for evaluation of defects in software engineering projects by NASA (Basili and Weiss 1984) and is widely used in software projects (Buglione and Abran 2000). However, GQM is also applicable in other disciplines such as software and information security (Savola 2008; Kowalski and Barabanov 2011; Kassou and Kjiri 2013), information systems (Kassou and Kjiri 2013; Esteves et al. 2003; Ganesan and Paturi 2009), and healthcare (Villar 2011). In the GQM approach, questions are derived from goals, and metrics are derived from questions (Basili et al. 1994): an organizational goal is associated with a measurement goal, as well as questions and metrics that help to obtain objective information about the success of goal attainment. Thus, at the operational level a set of questions are formulated to meet the specified goals, and finally, at the quantitative level, measures are defined to answer the questions quantitatively. The measured data can be objective such as work hours spent on a task as well as subjective, for example, level of satisfaction (van Solingen et al., 2002). Measures can be converted to quantitative values using Likert scales (Hansen and Birkinshaw 2007, Erkens et al. 2013; Ganesan and Paturi 2009).

The GQM approach is applied in identifying measures in innovation measurement models. For example, Hansen and Birkinshaw (2007) use key questions to identify measures that may be used to assess innovation practices, Enkel et al. (2011) use questions to measure innovation maturity levels in an organization and Tidd et al. (2002) and Gamal et al. (2011) use a set of questions to assess dimensions of innovation in the "Diamond Model".

2.3 Balanced Scorecard

The Balanced Scorecard (BSC) is a strategic tool that enables identification of strategic measures to estimate the impact of open innovation (Flores et al. 2009). BSC is a multidimensional framework that relates objectives, initiatives, and measures to an organization's strategy at all levels (Kaplan and Norton, 1996). The perspectives of BSC are Financial to measure business performance, Stakeholder to measure customer satisfaction, Internal Process to measure efficiency, and Learning & Growth to measure knowledge and innovation.

The GQM and the BSC cover different aspects of measures. For example, a higher level strategic perspective is missing in GQM, while strategic goals can be addressed using BSC (Buglione and Abran 2000). Also, the use of both approaches in combination is productive (Buglione and Abran 2000). GQM and BSC have similarities related to the way they derive metrics. For example, BSC uses goal-driver-indicator to derive metrics in a similar fashion as GQM does. The difference is that the GQM applies to multiple contexts while the BSC has a structure to facilitate the alignment of operational goals and business goals (Buglione and Abran 2000). The BSC's perspectives can be integrated by including GQM to elicit measures by identifying the goals, questions and metrics for each perspective of BSC (Buglione and Abran 2000).

2.4 Quality Improvement Paradigm

The Quality Improvement Paradigm (QIP) has a six-step cycle that emphasizes continuous improvement and is based on the Shewart-Deming Cycle Plan-Do-Check-Act (PDCA) (Basili et al. 1994). The PDCA is a widely-known model for continuous process improvements; it explains how an organization plans, does what has been planned, checks to see if what has been planned is done and acts on what has been learned (Johnson 2002). The QIP uses the GQM paradigm for evaluating and articulating a list of operational goals using measurement (Basili et al. 1994). The six steps of QIP are 1) characterize: understand environment and establish baseline with existing business process and also use knowledge gained from previous projects, 2) set goals: identify goals, based on step 1, that lead to success in the project, 3) choose process: choose suitable processes based on step 1 and 2, 4) execute: execute processes and provide project feedback based on data collected on goal achievement, 5) analyze: at the conclusion of the project collect data and make analysis to assess current practice, identify problems, and make recommendations for future projects, and 6) package: combine knowledge gained from the current project with previous projects and store it for future projects.

3 Method

The aim of this study is to design a method, the DRD-method, that addresses the lack of innovation measurement methods for the domain of digital innovation contests using open data. In order to meet the research aim we utilize components from goal oriented and quality improvement paradigms. By doing so we will also provide a way for organizers to perform measurement of digital innovation contests. To do so, we choose the design science approach suggested by Peffers et al. (2007). It consists of six activities: problem identification, objectives of a solution, design and development, demonstration, evaluation, and communication.

The work presented here builds on the work by Ayele et al. (2015). In Ayele et al. (2015) a model, the DICM-model, was designed and demonstrated also using the design science approach by Peffers et al. Hence, the work presented in this paper could be viewed as a second design iteration that builds on the results of Ayele et al. (2015).

3.1 Method for problem identification

Problem identification was carried out through a combination of an evaluation of the DICM-model (Ayele et al., 2015) and a literature review.

The evaluation of the DICM-model occurred ex ante (Pries-Heje et al. 2008). A purposive sample of 13 experts were carefully selected to evaluate the DICM-model, see Table 2. The experts were experts in organizing digital innovation contests for public and private sector organizations in different domains. Also, some of the experts were experienced in managing idea competitions, and innovation contests where the outcome can be a digital service, gadget, or business idea. Evaluation of the DICM-model, as part of problem identification, was carried out using semi-structured interviews with a supporting questionnaire. The interviews were recorded and transcribed. Thematic analysis was used to identify, analyze, and report themes and patterns of collected data (Braun and Clarke (2006). As a starting point for the analysis, we applied the so-called SWOT framework (Hill and Westbrook, 1997) to identify strengths, weaknesses, opportunities, and threats of the DICM-model.

A literature review was carried out to identify the relevance of goal oriented evaluation and its applicability in measuring innovation. We used a combination of keywords such as goal oriented measure, digital innovation contest, innovation measurement, open data innovation, goal oriented measures, and goal question metrics to locate relevant scientific works.

Table 2: List of respondents represented for simplicity as "RX" where R stands for the respondent and X stands for the index number.

Respondent	Digital Innovation Contest	Role
R1	Nasa Space Apps Challenge 2015, Prototype Change Hackathon	Consultant (Sweden)
R2	Apps4Finland 2013	Project Manager (Finland)
R3	Electricity Innovation Challenge 2015	Organizer (Sweden)
R4	TravelHack 2011	Project Manager (Sweden)
R5	Volvo Truck Open Innovation Contest 2015	Project Manager (Sweden)
R6	Olympic City Transport Challenge	Project Manager (Sweden)
R7	Volvo Goods Distribution Challenge 2014	Project Manager (Sweden)
R8	Singapore Management University Youth Innovation Challenge	Senior Management (Singapore)
R9	Thessaloniki Innovation Zone	Development Manager (Greece)
R10	Open Stockholm Award 2011 and 2014 and the UMIS project in Rio 2016	Project Manager (Sweden)
R11	Sweden Robot Hack 2013 and East Sweden Hackathon	Project Manager (Sweden)
R12	University of Nicosia Digital Championship	Project Manager (Cyprus)
R13	LU Open Innovation	Project Manager (Sweden)

3.2 Method for identifying objectives of the solution

The design objectives of the proposed DRD-method focus on enabling the design and refinement of DICM-models through a top-down approach considering variations in organizers' goals. The objectives of the method were elicited based on the problem identification (Section 3.1) and a literature review on goal-oriented approaches, including QIP, GQM and BSC. Accordingly, problem identification enabled us to identify some of the design objectives of the solution, enabling the customization of existing DICM-models to a given context.

3.3 Method for design and development

After identifying the problems of the Ayele et al.'s DICM-model, we started to explore ways to make the DICM-model adaptable to contests with various goals in different contexts. The design of the proposed method was informed by the design of goal-oriented approaches for measuring innovation and software development identified in the literature review and the expert evaluation. The DRD-method was designed by creating a sequence of activities, using components of the identified methods, while keeping core ingredients of the DICM-model as a framework of elements from which organizers could select applicable ones. The framework of elements consists of inputs, activities, outputs and measures organized according to an Innovation Value Chain, see Appendix 1 and 2.

3.4 Method for evaluation and communication

Two evaluations have been carried out ex-ante by groups of experts. In this case, ex-ante means that the artefact has been evaluated prior to real use in any innovation contest. The first evaluation was conducted as part of problem identification where the object of evaluation was the original DICM-model. The second evaluation was performed to evaluate the designed DRD-method. We used purposive sampling of experts from different digital innovation contests to ensure validity. The DRD-method was evaluated ex-ante by six of the 13 experts illustrated in Table 2 (R3, R4, R7, R9, R10, R12). The evaluation was carried out using semi-structured interviews thereby showing the viability of the method. Also, the method was presented in an international workshop.

4 Result

4.1 Problem identification

The ex-ante expert evaluation of the DICM-model indicated that there is a need for a method to design measurement models for digital innovation contests meeting differences in requirements of contest organizers. According to the experts, the original DICM-model partially enables the measurement of innovation contests based on available data (R1, R2, R3, R4, R5, R7, R8, R12), but it lacks support to provide all relevant measures for a given contest (R13). Moreover, it lacks contextualization based on contest goals (R8) and flexibility to customization (R2). For example, integrated process phases need integrated activities to be rearticulated (R8). Also, activities, inputs, outputs, and measures in each phase of a given contest are dependent on the context of the contest (R8). The DICM should be redesigned to increase its usability (R5, R8). The literature review helped us to identify similar situations, where top-down oriented measurement approaches have been used to handle variations in goals and contexts. Measuring software development in general being one such situation.

4.2 Objectives of a solution

The objectives of the proposed method are based on the problem identification in Section 4.1 and relevant parts of the objectives for the design of the original DICM-model (Ayele et al. 2015).

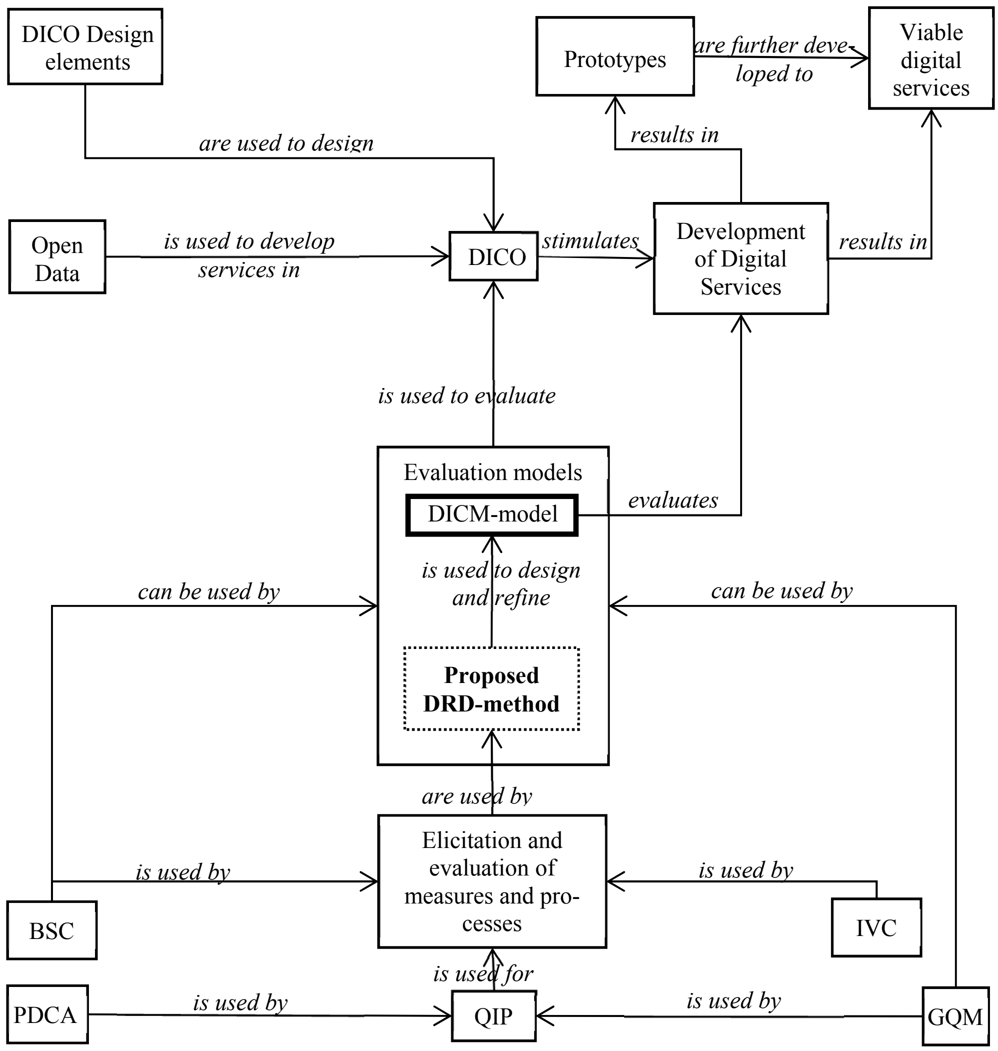
1. To aid in identifying relevant components of DICM-models such as processes, phases, measures, and other elements for new or modified DICM-models from goals of contests.
2. To aid in designing DICM-models based on identified components from the previous objective (1).
3. To aid in designing DICM-models that identify strengths and weaknesses in the innovation value chain.
4. To aid in refining DICM-models in use, based on feedback from on-going contests.

5. To aid in designing DICM-models that support learning and knowledge management in the development of digital services.
6. To aid in adapting previously designed DICM-models.
7. To be easy to use by organizers of innovation contests.

4.3 Design and development of the method

We combined components from different methods and paradigms such as GQM, QIP, BSC and IVC to design the DRD-method, refer to Figure 2. Hereby it is possible for contest organizers to design DICM-models applicable to different goals and contexts. We adopted the six steps of the QIP as a basis for the DRD-method. The proposed DRD-method has three phases consisting of nine steps. An illustration of how the six steps of the QIP are mapped to the nine steps of the DRD-method is shown in Table 3.

The first three steps in the QIP, *Characterize*, *Set goals*, and *Choose process* are articulated as *Characterize*, *Set measurement goals*, and *Build measurement model,* respectively, in Phase 1 using GQM and BSC as measure eliciting techniques. The fourth step in QIP, *Execute*, is mapped into three steps in the DRD-method, *Analyze result*, *Measure*, and *Provide immediate feedback* in Phase 2. The fifth step in QIP, *Analyze* is mapped to *Analyze* in the third phase. Finally, the sixth step, *Package*, in QIP, is mapped into two steps, *Package* and *Disseminate*.



Legend:
Read the diagram by following the direction of the arrows, for example you can read the relationship between the PDCA and QIP as "PDCA is based on QIP".
DICO – Digital Innovation contests
BSC – Balanced Scorecard
DICM – Digital Innovation Contest Measurement
DRD – Designing and Refining DICM
PDCA – Plan-Do-Check-Act
QIP – Quality Improvement Paradigm
GQM - Goal Question Metrics
IVC – Innovation Value Chain

Figure 2: Central concepts of the DRD-method, illustrating how it is positioned to design and refine the DICM-model.

Table 3: Illustration of how the Six Steps of the QIP are mapped to the Nine Steps of DRD-method.

	QIP by NASA (Basili et al. 1994)		The proposed DRD-method			
Corporate feedback cycle (Capitalization cycle)	1: Characterize		Characterize		Phase 1: Designing DICM-model	Organizational learning
	2:Set goals		Set measurement goals			
	3: Choose processes		Build measurement model			
	4: Execute	Project feedback (Control cycle)	Measure:	Project learning	Phase 2: Refine model in use	
			Analyze result:			
			Provide immediate feedback			
	5: Analyze		Analyze		Phase 3: Learn and communicate	
	6:Package		Package			
			Disseminate			

4.3.1 The DRD-method

The DRD-method consists of three phases divided in nine steps, see Figure 3. Below each of the phases and steps are described and justified in more detail.

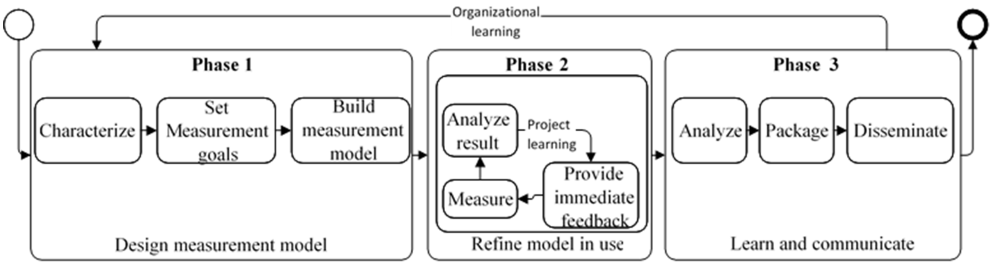


Figure 3: A nine-step method to design and refine evaluation models for assessing digital innovation contests.

Phase 1: Design measurement model

In this phase, an organizer carries out the activities listed in steps 1, 2, and 3 to design a measurement model for a specific digital innovation contest.

Step 1. Characterize

In this step, organizers elicit contest requirements, understand contest goals, and design processes. Organizers can also use accumulated knowledge so that previously used models and best practices can be customized to current requirements. Theoretical foundations are also be used to characterize innovation contests and post contest deployments.

Justification for including the Characterize step

The ex-ante evaluation of the original DICM-model indicated that there is a need for a pre-planning phase before the planning phase of the DICM (R1, R9). Similarly, Basili et al. (1994) suggest characterization as a step where understanding the environment based on available models, data, intuition, etc. to establish a baseline with existing processes in the organization. Hence, old DICM-models from previous contests can be used as an input in this step. One can also use best practices as suggested in the characterize step by Basil et al. (1994). Similarly, previously used models can be adapted to current design or customization endeavors. It is also suggested to consider previous evaluations (R2) when contests are run annually or periodically (R8). The method supports management of best practices (R12).

Step 2. Set measurement goals

Organizers can identify relevant perspectives such as financial, innovation, customer, and others to address strategic objectives, goals, as illustrated in Figure 5. In addition, organizers are advised to identify and list goals specified by contest owners. If these goals are not specified in detail, then organizers should redefine them to the most granular detail to facilitate their fulfillment. Organizers verify the relevance of goals and sub-goals identified by contest owners. In parallel, they can categorize these goals under the Balanced Scorecard perspectives as illustrated in Figure 5. Finally, questions that could be asked to assess if goals are fulfilled need to be articulated.

Justification for including the Set measurement goals step

The assessment of the DICM-model presented in (Ayele et al. 2015) indicated that the goals of a given contest are not fully evaluated because the DICM-model only addresses contest goals partially. Besides, innovation contests depend on the aim of the whole process (R4, R8 R11). Therefore, identifying goals is a crucial step in designing digital innovation contests. Questions can be derived from goals (Basili et al. 1994), and questions need to be articulated to measure goal fulfilment at each stage (R8). Goals and their corresponding measures can be identified under each perspective as illustrated in Figure 5. Similarly, questions are presented to identify or relate metrics (Hansen and Birkinshaw 2007; Enkel et al. 2011; Tidd et al. 2002; Gamal et al. 2011).

In cases where companies have innovation as one of their development strategies, additional performance measures are required (R7). Therefore, innovation and other organizational perspectives can be included to measure strategic performance. The perspectives such as financial, customer, internal process, and learning and growth can be included. Also, the perspective people are added in the Balanced IT Scorecard (BITS) (Buglione and Abran 2000).

Step 3. Build measurement model

Organizers identify, define and describe processes, phases, inputs, activities, outputs and measures of their DICM-models based on characteristics and questions. Since questions are derived from goals and metrics from questions, the GQM paradigm is an important mechanism for building the measurement model. Identification of required data sources is also an important activity when building a measurement model. Qualitative measures such as market potential can be assigned scales from 1 to 5 with quantitative ordinal values with labels: very insignificant, insignificant, neutral, significant, and, very significant correspondingly. The identification of measures, referred as metrics in GQM paradigm, is illustrated in Figure 4 below. The identification of metrics can also use the BSC, the Goal-Driver-Indicator for each strategic objective as discussed in Section 2.5. Besides it is similar with GQM, where driver has the same purpose as question and indicator is interchangeable with metrics (Buglione and Abran 2000). Measurement perspectives can be financial that deals with business performance, stakeholder to deal with customer satisfaction, internal to measure efficiency, and learning and growth to measure knowledge and innovation. Relevant perspectives can be formulated by organizers to measure organizational strategic goals relevant to contests and the outcomes, see Figure 5 for illustration.

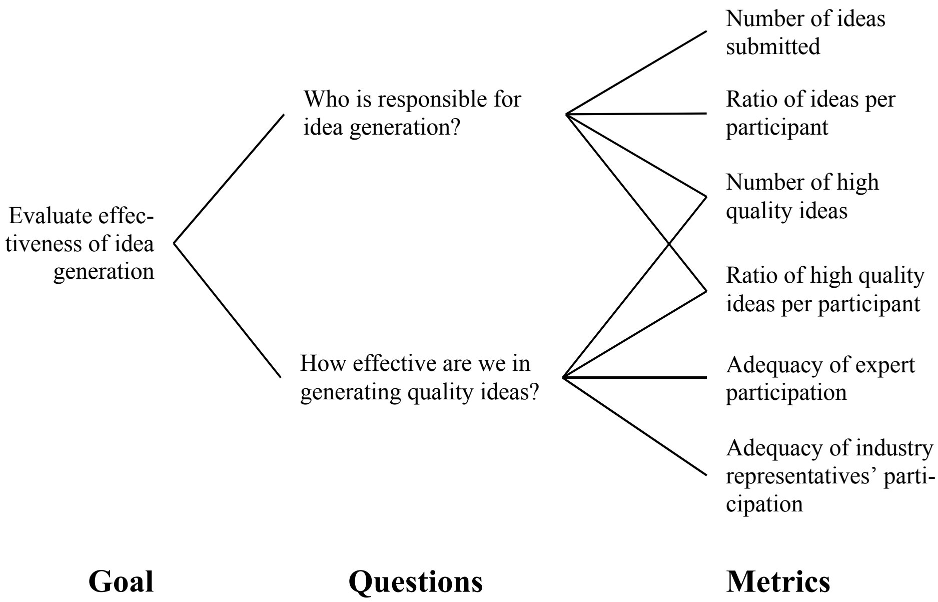


Figure 4: an example illustrating how relevant questions can be derived from goals and metrics can be derived from questions.

To aid organizers in identifying relevant elements of their model, a framework of elements was assembled. The framework is based on an extended version of the original DICM-model and consists of inputs, outputs, activities, and measures organized according to an Innovation Value Chain, see Appendix 1 and Appendix 2.

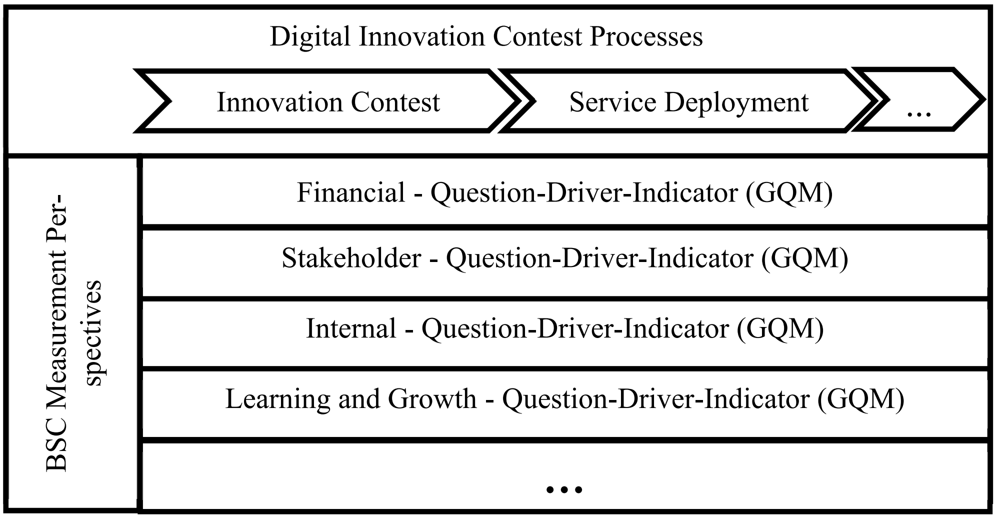


Figure 5: BSC Perspectives with DICO strategic goals and the corresponding GQM aligned with DICO processes.

Justification for including the Build measurement model step

The innovation contest and the service deployment processes of DICM-model by (Ayele et al. 2015), are relevant according to most respondents. However, additional inputs, activities, outputs, and measures were also suggested since the goals of each respondent, contest organizer, are contextual. Therefore, one can take the two processes of the modified DICM-model and customize it using the DRD-method to identify relevant elements. However, some experts also suggested new processes and phases as discussed in the Theoretical Framework Section. Digital innovation contest processes depend on the goals of the whole innovation process (R4, R8, R11). Also, Basili et al. (1994) stated that based on the characterization of the goals and the environment organizers need to choose their processes. So, organizers need to define their processes and identify phases, inputs, outputs, and activities if their processes are different from the processes of the DICM-models. Activities of DICM-models can be formulated from goals of innovation contest (R6, R11). Also, activities in cases when phases are merged into one phase need to be rearticulated and integrated measures need also be identified (R2, R5, R12). Metrics can be identified based on goals (R4). More specifically, identification of metrics is done by articulating questions from goals, then deriving metrics from these questions, and finally deriving metrics that can answer these questions (R8), (Basili et al. 1994). Additionally, goals can be mapped into perspectives as shown in Figure 5 to measure strategic objectives. To measure qualitative metrics quantitatively, a Likert scale can be used as illustrated by (Hansen and Birkinshaw 2007; Erkens et al. 2013). Organizers also need to identify data sources (R10).

Phase 2: Refine model in use

In this phase, organizers assess contests and service deployments by following the guidance listed under Phase 1, Steps 1, 2, and 3. Hence, after measuring the current phases of contest processes, organizers analyze the result and provide immediate feedback.

The feedback itself is utilized to improve performance and make modifications to the model in Section 4.4, Measure. This Phase is iterative until the organizer decides to terminate the contest.

Step 1. Measure

In this step, organizers start the innovation contest by setting a timeline for each phase of the DICM model within the deadline set by the contest owners. Similarly, if organizers support service deployment, they start service deployment of the DICM by setting time for each phase. Organizers follow the timeline to execute activities in each phase of DICM using inputs to produce outputs and collect measures to provide execution feedback at each phase. Execution is an iterative step with three sub-steps. The first step is execution where organizers allocate or reallocate time for each innovation contest process and service deployment phase and starts executing activities; organizers also follow execution feedback if the phase in the innovation contest or service deployment is redone. Finally, the third sub-step is to provide execution feedback by compiling measured performances; then finally organizers decide to conclude execution of the current phase and continue to the next phase, or re-execute the current phase.

Justification for including the Measure step

Organizers start the execution of digital innovation contest or service deployment processes by allocating timeline for each process according to the deadline set by the contest owners (R11). In addition to these, organizers follow their model to execute activities to convert inputs into outputs at each phase, which is a recursive process (R12). Measures, such as availability of resources, can be used to monitor utilization of resources by comparing the cost and returns (R7). Also, project analysis and then feedback can be obtained after collecting data regarding the assessment of goal achievement (Basili et al. 1994).

Step 2. Analyze result

In the second sub-step, organizers start analyzing the collected measures to identify deviation and their root causes. Also, organizers suggest coping strategies of barriers encountered.

Justification for including the Analyze result step

Measured phases need to be analyzed to provide feedback for improvement during execution as suggested by all respondents. Analyzing results to provide project learning is essential for quality improvement (Basili et al. 1994).

Step 3. Provide immediate feedback

In this step, organizers compile and communicate measured performances to suggest improvements to the DICM-model in use. Organizers improve the current DICM-model to reflect the current contest situation, for example, if feedbacks indicate that there are inputs, activities, and or/outputs which need to be incorporated in a given phase of the DICM-model, then these elicited refinements are made to the measurement model.

Justification for including the Provide immediate feedback step

Organizers measure to provide feedback during execution. Feedback control cycle is used for monitoring utilization of resources (Basili et al. 1994).

Phase 3: Learn and communicate

This phase illustrates the management of knowledge by storing best practices after notifying problems collected during measurement to evaluate current practices and identify lessons learned. These experiences are then stored in the knowledge base and communicated to future organizers and the scientific community as described in Steps 1, 2, and 3 below.

Step 1. Analyze

After the contests, organizers analyze measurement of data, analyze current practices to identify problems, record findings and make a recommendation of best practices.

Justification for including the Analyze step

Analyzing data and information collected during the course of the project is useful for future recommendation of best practices. The analysis of data and information is done by identifying challenges, evaluating the current model and recording best practices and experiences (Basili et al. 1994). All respondents agreed that the method facilitates identification of strengths and weaknesses, and fulfilling goals of contests.

Step 2. Package

Organizers update information gained from the current DICM-model if it is a customized design. If it is a new model, it will be stored as a new model with experiences gained from using it. Also, organizers combine the experiences gained as new if the measurement model they have used is a brand-new setting and finally they store the knowledge gained in an experience database to avail it for future projects.

Justification for including the Package step

Combining and storing experiences in the form of a model and other structured information make them available for future projects (Basili et al. 1994). Similarly Also, improvement suggestion of the current DICM-model is stored to copy feedback for future usage (R2, R8). At the end of the project, best practices, in a similar fashion as QIP, are accumulated and combine experiences for future utilization (Basili et al. 1994). In addition to the knowledge management facility provided by the method (R12), the method enables learning and increasing maturity (R4, R7, R9, R10, R12).

Step 3. Disseminate

The purpose of this step is to disseminate lessons learned from digital innovation contests. Lessons learned are communicated including the applicability of the measurement model to practice and science.

Justification for the Disseminate step

The feedback cycle in this step is called capitalization cycle which provides performance information at the end of the project to enable reuse and accumulation of best practices in a similar fashion as QIP (Basili et al. 1994). The method, in addition to its learning and increasing maturity facility (R10), includes a knowledge management facility (R12). Five of the six experts agreed that learning and increasing maturity can be adequately facilitated by DICM-models.

4.4 Communication and evaluation of the proposed method

To assess the DRD-method, the method was orally communicated to six experts (R3, R4, R7, R9, R10, R12) using examples and illustrations. An ex-ante evaluation of the method was conducted using semi-structured interviews of the six experts. The interview results were analyzed thematically to identify strengths and areas for improvements.

The evaluation indicates that all three phases of the method and their corresponding steps are considered valid (R3, R4, R7, R9, R10, R12). In addition, all design objectives in section 4.2 are met by the method. For example, the assessment of the nine-step method indicates that it aids in managing best practices, and those organizers who decide to maintain best practices will benefit (R12). All six respondents (R3, R4, R7, R9, R10, R12) agreed that the method aids in identifying strengths and weaknesses in the innovation value chain in addition to enabling the design of DICM-models. Hence the analysis of measurement is a logical step. R6 also argued that the method aids in managing knowledge. The method enables learning and increasing maturity (R10). All experts except R3 agreed that learning and increasing maturity can be adequately facilitated by using the method (R4, R7, R9, R10, R12).

Finally, from the six respondents, one expert was interested in using the method and three experts agreed that the DRD-method is usable. However, two experts are not sure about the usability of the method although one of these experts reflects that it enables the inclusion of relevant metrics for the evaluation of digital innovation contests. For example, R9 showed interest in using the DRD-method, "with this material and the discussion I had the opportunity to have with you during our meeting in my office the whole methodology is quite clear to me". R9 promised to use the proposed method, "to the extent of our experience we will try to implement the methodology you propose to evaluate a future competition and will get back to you with the outcome and suggestions if any." Similarly, R4, R10 and R12 gave positive feedback regarding the usability of the method. In contrast, R3 and R7 are not sure if the steps involved are easy to use, but R7 thinks that the method enables the inclusion of metrics that can measure goal of contests.

5 Discussion

Open data provision creates the potential for social and business value creation (Lindman et al. 2013). Contests have become leading means to stimulate innovation of digital services based on open data and to facilitate the utilization of open digital resources (e.g. open data) (Hjalmarsson and Rudmark 2012). Consequently, the availability of innovation measurement models for the contest domain driven by open data is vital for the success of efforts to stimulate innovation based on accessible digital resources. The DRD-method presented in this paper, accompanied with the framework of elements, see Appendix 1 and Appendix 2, provides an important tool in the toolbox for contest organizers to evaluate open digital innovation (Hjalmarsson et al. 2017).

The DRD-method complements available methods for measuring innovation. It is specifically designed for evaluating digital innovation contests and pendant service deployment processes and consequently adds a supplementary toolset for innovation measurement tailored for the contest domain. None of the available methods addresses the domain of digital innovation contests using open digital resources. For example, the framework by Erkens et al. (2013) is designed for measuring open innovation with ideation as one of its methods, but is designed from the perspectives of innovation managers and performance consultants for organizations aiming to succeed in the market. Hence, it doesn't cover the aspect of digital innovation contest in particular. Another example is the framework by Washizaki et at. (2007) which is used to assess software quality in designing embedded technology for robotics. More general methods are designed to measure innovation in product, process, marketing, and organization (Mortensen and Bloch 2005) while others are designed to measure innovation in nations, industry and organizations (Mairesse and Mohnen 2002).

Problem identification through the ex-ante evaluation of the original DICM-model by Ayele et al. (2015) showed that measurement models for digital innovation contests need to be adaptable to different contest conditions, measure different processes, include feedback loops and iterations and cover other inputs, outputs, and activities and measures than those included in the original version of the DICM-model. To address these limitations, we introduced and empirically grounded a nine-step method to design and refine models for evaluating digital innovation contests. The method addresses the dynamic organizational requirements for creating a DICM-model. The proposed nine-step method to design or adapt and refine DICM-models has three iterative phases with nine steps grounded in the QIP (c.f. Basili et al. 1994). Phase 1 enables the design and customization of DICM-models including feedback for customization and characterization from previous projects. The design of the customized DICM is then carried out using the GQM paradigm and the BSC. The DRD-method is informed by models and frameworks such as the Innovation Value Chain (Hansen and Birkinshaw 2007), Diamond Model (Tidd et al. 2002; Gamal et al. 2011), Innovation Funnel Model (Morris 2008), Open Innovation Maturity Framework (Enkel et al. 2011), and Goal-Driven Measurement for Software Innovation Process (Misra et al. 2005) to identify measures. Phase 2 explains how innovation contest processes can be iteratively assessed to provide feedback and learning within the project. Finally, phase 3 is used to manage best practices by identifying problems, documenting best practices, and packaging lessons learned to facilitate re-use of experiences to adapt and refine the adopted evaluation model (c.f. Basili et al. 1994).

The nine-step DRD-method to adapt and refine DICM-models scores high regarding relevance when cross-checked with the expert respondents' experiences. The majority of the experts especially points out the feedback loop as an important strength of the method. This feature supports the organizers of digital innovation contests to adapt the assessment model during the contest, as well as to collect and package experiences that will support future digital innovation processes driven by open digital resources. This enables digital innovation contest driven by open data to not only be "one-time" events. The structured capability to package experiences and lessons learned enable organizers to be evolutionary unleash the value of open digital resources, e.g. open data, can create (Lindman et al. 2013).

The method has implications for the Innovation Value Chain approach to organizing innovation with its focus on digital innovation contests. The Innovation Value

Chain (c.f. Hansen and Birkinshaw 2007) provides a sequential and rather closed process as a basis for innovation measurement. The DRD-method offers a local crosscheck (Bielkowicz et al. 2002), from the perspective of contest organizers, that supports the notion that innovation processes are iterative (Kline 1985) and open (Chesbrough 2003) with feedback loops (Kline and Rosenberg 1986). Hence innovation measurement must also be based on open innovation processes in a similar fashion as suggested by Edison et al. (2013) and be supported by tools that enable organizers to adopt evaluation models that adhere to the specific prevailing conditions.

Finally, we found it somewhat difficult to differentiate between the design and construction of (paper-based) models and methods. It is obviously easier to draw a line between a software design and a constructed and executable software (Sonnenberg and vom Brocke 2012). Although the evaluation of the original DICM-model was made through a demonstration of the model, populated with data from a real contest, it was still considered an ex-ante evaluation. We decided to differentiate between design and construction of (paper-based) models and methods based on the criterion if the model or method were used in a real contest or not.

5.1 Limitations

We carefully selected participants for the expert panel based on their knowledge and experience of organizing various types of digital innovation contests in complementary contexts. However, we cannot fully rule out that selecting other participants would have revealed other findings, given other industry backgrounds, roles, and contexts. Although the respondents' expertise counteracts the limitations of only using ex-ante evaluations, we are aware that ex-post evaluations may reveal other important insights in the construction of the DRD-method.

6 Conclusions and Future Research

The aim of this paper was to propose a method for designing and refining measurement models for digital innovation contests. A method for designing and refining DICM-models, the DRD-method, was developed to meet specific needs of different digital innovation contests. It fills a gap in innovation measurement by providing a method for the emerging domain of digital innovation contests using open digital resources. The DRD-method contributes with an "Exaptation" (Gregor and Hevner, 2013) by extending innovation measurement to the application domain of digital innovation contests. Based on the ex-ante expert evaluation, we conclude that the DRD-method provides comprehensive support in designing and refining DICM-models and that the method supports reflection and refinement in use and provides a foundation for organizational learning across several contests. Also, it confirms the claims made by Edison et al. (2013) that innovation measurement needs to take into account the iterative and open characteristics of innovation. Hence, it also provides an "Improvement" (Gregor and Hevner, 2013) of innovation measurement as it represents a new solution for a known problem.

For future study, we suggest a more rigorous evaluation of the DRD-method, including ex-post evaluation of the method in conjunction with real contests. We also propose systematic efforts to generalize the method within as well as beyond the context of the contest. This to support the design of open innovation measurement models corresponding to variations in goals, processes and forms for how to accelerate and organize open digital innovation; e.g. as a contest, a hub, a garage or an accelerator (Juell-Skielse and Hjalmarsson 2017). Finally, we propose to further investigate the potential of top-down and goal oriented approaches to measure open and iterative forms of innovation.

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Appendix: Framework of Elements

Appendix 1 - Innovation Contest Process

Modified Innovation Contest Process			
Phases	**Planning**	**Ideation**	**Service Design**
Input	Resources, for example API info, open data sources, domain knowledge, financial resources, inputs from other competitions (R2, R8), prototype from previous innovation (R11), experts (R12)	Time, resources and facilities, inputs from other competitions (R2), domain knowledge (R3), experts and knowledge resources (R12)	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 d. Represent recursive (R12) e. Add time line (R11) f. Generate or look for funding (R2, R3) g. Convincing people to get the inputs (R3) h. Early involvement participants (R3, R5) i. Preparation of the facilities (R5) j. Meetings with stakeholders (R6) k. Determine what kind of data sources should be available (R6, R10) l. Plan and design ideation and service design (R6) m. Specify what the contest should focus on (R6) n. Specify what teams can win (R7)	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 c. Represent recursive (R12) d. Add time line (R11) e. Define size of teams(R1) f. Curate participants (R1) g. Making prototyping material available (R1) h. (select finalists (R2,R3, R6, R9)) i. Support the evaluation of ideas (R3) j. Preparation of the facilities (R5) k. Select finalist and winners (R5) l. Confront contestants with actual problem owners (R7) m. Get the right set of judges (R8)	a. Support in service design, e.g. hackathon, technical support, business model support b. Select winners: evaluate prototypes and business models c. Represent recursive (R12) – if the output in this phase is invalid output) then loop back to ideation else continue d. Add time line (R11) e. Making prototyping material available (R1) f. Testing of ideas and implementations (R2) g. (Select winners (R2) h. Marketing prototype (R4) i. Presentation of prototypes (R4) j. Facilitate financial or funding support (R7)

	o. Involve relevant actors in supporting the contest, formulating problem solution maturity (R7) p. Setup evaluation criteria (R8) q. Contextualize to setup evaluation criteria (R8) r. Participants submit ideas (R9) s. Evaluate ideas (R9) t. Select finalists (R9) u. Talk to key persons in the organization to decide activities (R10) v. Identify important services (R10) w. Participate in social media (R12) x. Enlist sponsors (R13) and supporters (R12) y. Facilitate hackers and problem holders to discuss (R13)	n. Formulate the right parameters for judging (R8) o. Contextualize to setup evaluation criteria (R8) p. Select finalists: (evaluate pivots and business models (R9)) q. Manage IP rights and visibility (R9) r. Evaluate market potential (R9) s. Coaching (R12) t. Specialized guidance and support u. Participate in social media (R12) v. Locate sponsors, hackers, contestants benefits	k. Facilitate legal support to ensure IP rights (R7, R9) l. Engage external actors as member of jury, help in formulating (R7) m. Evaluate ideas (R9) n. Select finalists R9) o. Select participants to the demo day (R9) p. Go no go decision to continue to service implementation (R9) q. Provide support related with data (R10) r. Participate in social media (R12) s. Promote idea of innovation (R12) t. Evaluate prototype and business model
Output	Registered participants ready to contribute to the competition	High quality digital service ideas, concepts (R3), media attention (R3), concrete digital services (R9), low fidelity prototype (R12), digital services (R12), description of design (R12)	High quality digital service prototypes, media attention (R3), concrete description of the product to be developed (R9), useful digital services (R10)
Measures	▪ Available resources ▪ Problem – solution maturity ▪ Contest quality ▪ Visibility ▪ Number of participants ▪ (Problem – solution maturity (R2, R8, R9)) ▪ Number of participants (R2, R3) ▪ Number of registered participants (R3) ▪ Number of Twitter Hash tags (R7, R10) ▪ Number of countries represented (R8)	▪ 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 ▪ Number of high quality digital service ideas ▪ Visibility	▪ 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 participant ▪ Number of high quality digital service prototypes

	▪ How many organizations have been involved (10) ▪ Number of interested people (R12) ▪ Number of Facebook fans (R12)	▪ Visibility (R1, R7)) ▪ Problem – solution maturity (R2, R8)) ▪ Time invested by participants (R2) ▪ Actual number of participants (R3) ▪ Number of submitted prototypes (R5) ▪ Number of teams (R5) ▪ Number of visits (R5) ▪ Availability of data sources (R6) ▪ Teach participants how to evaluate their idea (R9) ▪ Easy to use (R10) ▪ Level of satisfaction of participants (R11) ▪ Level of satisfaction of sponsors (R11) ▪ Number of experts participating in technical support (R12) ▪ Number of industry representatives (R12) ▪ Time invested in structured activities (R12) ▪ Number of Facebook fans (R12) ▪ Number of final submissions (R12)	▪ Visibility ▪ Number of market applicable solutions (R1) ▪ Quality of the event (R1) ▪ (Problem – solution maturity (R2, R8)) ▪ (time invested by participants (R2)) ▪ Satisfaction level of funders (R2) ▪ Satisfaction level of organizational partners (R2) ▪ Percentage of participants that want to go to service deployment (R3) ▪ Potential of the prototype to be implemented (R4) ▪ Number of downloads (R6) ▪ Number of Hashtags or Twitter tags (R7) ▪ Number of Facebook fans (R12) ▪ Number of final submissions (R12) ▪ Time invested in structured activities (R12) ▪ Resource includes prize or award (R12)

Appendix 2 - Service Deployment Process

Modified Service Deployment Process			
Phases	**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	a. Support service implementation at	a. Support service delivery at various

	b. Establish goals for service deployment c. Organize resources based on goals (in a) d. Go/No go decision e. Represent recursive (R12) f. Add time line (R11) g. Contextualize or setup evaluation criteria (R8) h. Get sponsors (R13) i. Evaluate teams potential (R1) j. Take care of ownership right (R1) k. Make agreement or contract with the team (R1) l. Involving participants in planning (R3) m. Early involvement of customers or users (R6) n. Estimate cost and revenue (R7) o. Facilitate or arrange external funding (R7) p. Evaluate market potential (R7) q. Go no go decision (R7) r. Articulate go no go decision (R8) s. Establish set of question I should ask to arrive at go no go (R8)	various levels (from no support to very high support) b. Evaluate service quality c. Evaluate market potential d. Go/No go decision e. Represent recursive (R12) f. Add time line (R11) g. Contextualize to setup evaluation criteria (R8) h. Help them find funding (R3) i. Evaluate business model (R3) j. Help them find and get access to project people (R3) k. (evaluate market potential (R7)) l. Evaluate customer by doing pre-launch (R7) m. Make marketing plan (R7) n. Test the first version on the potential of customers (R7) o. Have marketing channels in place (R7) p. Provide data support and if necessary real time data support	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 d. Represent recursive (R12) e. Add time line (R11) f. Contextualize or setup evaluation criteria (R8) g. (no service commercialization if the product is free)
Output	Prepared organization Validated business model (R8) (prepared organization (R8))	Viable digital service, business model and intellectual property	Service revenue, service value (R12)
Measures	▪ Level of post-contest support ▪ Available resources ▪ Level of commitment Post contest support utilization (R6)	▪ Available resources ▪ Quality of support ▪ Problem – solution maturity ▪ Service demand Revenue model (R9)	▪ Available resources ▪ Quality of support ▪ Problem – solution maturity ▪ Service usage ▪ Rate of diffusion

	▪ (Level of post-contest support) ▪ Evaluation of innovativeness (R8) ▪ Evaluation of market size (R8) ▪ Evaluation of market potential (R8) ▪ Evaluation of scalability (R8) ▪ (Level of commitment (R9))	▪ Forming alliance with 3rd parties (R12)	▪ Number of downloads ▪ Revenues Market potential (R1) ▪ (Service usage (R3)) ▪ (Rate of diffusion (R3)) ▪ (Number of downloads (R3)) ▪ Measure that combines: service usage, rate of diffusion, and number of downloads (R3) ▪ Number of apps in app store (R6) ▪ Customer satisfaction (R7) ▪ (Problem solution maturity (R9)) ▪ (revenue (R10))