FROM CONTEST TO MARKET ENTRY: A LONGITUDINAL SURVEY OF INNOVATION BARRIERS CONSTRAINING OPEN DATA SERVICE DEVELOPMENT

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Abstract

Open data services have emerged as a research field. One important area of investigation within this field is exploration into how sustainable open data markets are created. Contests have become a popular method to propel and catalyse open data service development providing services to such markets. Recent research has identified numerous innovation barriers hampering development adjacent to the contest in developers' effort to transform contest contributions to viable digital services based on open data. Little is however known about what innovation barriers over time constrain the post-contest process to transform initial innovations to finalized open data services ready for market entry. This paper presents a longitudinal survey of innovation barriers constraining teams performing open data service development after an innovation contest. The survey provides insights into 1) 24 innovation barriers constraining development, 2) a comparison of barrier importance based on team progress, and 3) a conceptualisation of phases structuring the process from contests to market entry, stipulating different innovation barriers impact open data service development. The results contribute to the understanding of how sustainable open data markets emerge and serve as a starting point for investigating how different stakeholders can manage innovation barriers constraining open data service development.

Keywords: Open Data; Innovation; Innovation Barrier; Innovation Contest; Longitudinal Survey

1 Introduction

By granting public access to organizational data, e.g. open architectures (Marton et al. 2013), substantial societal and business value can be created through open data services (Lindman et al. 2013). Open data service development is therefore an increasing practice involving third-party developers driven by different motives, commercial (Ceccagnoli et al. 2012) as well as non-commercial (Kuk and Davies 2011). Yet, while there are currently high hopes that open data may serve as a foundation for creating increased economic growth in the digital service development sector (European Commission 2011), open data service development has so far largely failed to live up to these expectations. Previous research studying the challenges to such development has found that data providers are struggling with the publication of data. Since such publishing is an emerging practice, much uncertainty surrounds it (Janssen et al. 2012). This uncertainty involves several aspects of data publishing such as privacy, legal issues and technical formats, but also how to prioritize publication of datasets with higher value creation potential (e.g. Lindman et al. 2013, Tammisto and Lindman 2012, Kuk and Davies 2011, Janssen, et al. 2012, Zuiderwijk and Janssen 2014).

In the wake of increased open data provision, innovation contests have emerged as a popular method to promote open data use, catalyse development of open data services and also to collect developers' experiences from using open data provided for digital service development. So called digital innova-

tion 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). While contests are becoming a more and more popular method to catalyse open data service development (Juell-Skielse et al. 2014), recent research (Hjalmarsson et al. 2014) indicates that 1) only a limited number of the contributions emerging from these events are transformed into open data services that reach the market, and 2) that teams closely adjacent to the contest face innovation barriers when transforming their contest contributions to open data services. Examples of barriers inhibiting developers after innovation contests are lack of time and money to continue development, lack of marketing competence and market information to develop a sound service that meets an actual need, and difficulties in creating a strong value offering for the contest contribution (Hjalmarsson et al. 2014).

While the recent research on inhibiting barriers (Lüttgens et al. 2014, Ghobadi and Mathiassen 2014) has provided sound insights using primary qualitative research approaches, little is still known about the barriers that affect open data service development over time. The aim of the research presented in this paper is to contribute to the on-going research into the logic of open data services (c.f. Lindman et al. 2013) by providing a longitudinal survey of *what innovation barriers constrains third-party developers in different phases when performing open data service development after innovation contests*?

Based on a theoretically anchored review of the areas open data service development, innovation contests and innovation barriers, the paper explores what barriers inhibit open data service development 18 months after an innovation contest; secondly this outcome is compared with data about perceived barriers collected two months after the same contest (Hjalmarsson et al. 2014). This unique comparison is used to investigate what barriers that constrain open data service development at different stages after the contest. In the final discussion three phases are elicited to structure the development process after innovation contests from the teams perspective, and the results from the longitudinal barrier survey are discussed in relation to these phases. Surveying and positioning innovation barriers constraining open data service development have high potential to make an impact. One area of application is to use the result as a base to develop and test attentive coping strategies for diverse stakeholders to manage barriers at different stages during development. Another is to investigate and determine how and when stakeholders can support third-party developers and thus how to strengthens open data markets.

The paper is organized as follows. Next the theoretical grounding is presented (section 2). Then follows a description of the case and the research method used (sections 3 and 4). In section 5 the results are presented as outlined above followed by a discussion (section 6) of implications for open data service development followed by conclusion and suggestions on future research (section 7).

2 Theoretical Grounding

The study builds on existing research in the areas of open data service development and innovation contests. Challenges for innovation contests are viewed through the lens of the literature on innovation barriers, which is used for describing and investigating barriers to open data service development.

2.1 Open data service development

"Open data" in this study refers to internal data passed on beyond an organizational border, also labelled open architectures (Marton et al. 2013), often made available through accessible Application Programming Interfaces (API) in machine readable formats (Marton et al. 2013, Latif et al. 2009). External innovators frequently use open data with this definition to develop novel digital services, i.e. open data services. In Lindman et al. (2013) a research agenda is introduced for open data services. This agenda is based on the knowledge gap of how to establish sustainable open data markets, namely marketplaces populated by interdependent stakeholders who supply and consume open data and digital services produced for this market (2012).

The rationale for providing open data on open data markets is to attract outside innovators to develop open data services that go beyond what existing services provide (Kuk and Davies 2011), and to increase value generated for end users or customers (Lindman et al. 2013, Deloitte 2012). Several challenges to perform open data service development have emerged which threaten the sustainability of

open data markets: make localization of particular datasets easy (Zuiderwijk and Janssen 2014), improve data quality, reduce license restrictions and ensure sustainability of data delivery (Janssen et al. 2012, Zuiderwijk and Janssen 2014).

Hjalmarsson et al. (2015) classify key stakeholders on open data markets in four types. Organizations, labelled as *data providers* (Lindman et al. 2013), pass on data beyond their organizational borders, and often invite outside innovators, also known as *third-party developers* (Rudmark 2013), to pursue open data service development, driven either by non-profit grounds (Kuk and Davies 2011, Juell-Skielse et al. 2014a) or business models (Ceccagnoli et al. 2012). In order to retain some control of the distributed process and at the same time attract third-party developers to use open data sources, open data brokers have emerged on the open data market. The *open data broker*, e.g. an organizer of a digital innovation contest (Hjalmarsson and Rudmark 2012) or a commercial or non-commercial data hub provider, arrange links between the third-party developers and data providers facilitating open data service development on the market. *Consumers* on the open data market use the results from the market to resolve challenges in their everyday situation (Hjalmarsson et al. 2015).

Little is known about the role and function innovation contests can have in establishing sustainable open data markets beyond catalysing development (Juell-Skielse et al. 2014b); even less is known about what requirements such a function brings to the design of innovation contests and the post-process that follows, when third-party developers should transform their contest contributions into open data services. By exploring barriers that third-party developers face after an innovation contest, this paper contribute to the knowledge base that explore how open data services are developed and how sustainable open data markets are established and retained (Lindman et al. 2013).

2.2 Innovation contests

The provision of open data currently receives much attention; however, as argued in the previous section, the market for open data is still in its infancy. Contests have become one important method to propel open data service development. In general contests are used in the early stages of innovation to stimulate the generation of ideas (Bullinger and Moeslein 2010) and service prototypes (Osimo et al. 2012), but also to influence development efforts to ensure that the results are aligned with organizational goals (Hjalmarsson and Rudmark 2012).

Different types of contests have been proposed to control and organize early open innovation: idea competition (Piller & Walcher 2006), community based innovation (e.g. Füller et al. 2006), online innovation contests (Bullinger and Moeslein 2010), and digital innovation contests (Hjalmarsson and Rudmark 2012). The relationship between contest types and forms of open innovation processes, i.e. inside-out, outside-in and coupled processes (Gassmann and Enkel 2004) has been elaborated on in Hjalmarsson et al. (2014). Bullinger and Moeslein (2010), Hjalmarsson and Rudmark (2012) and Juell-Skielse et al. (2014b) furthermore present design elements to be used by organizers to design a proper contest process for the organizational goal at hand.

Recent research emphasizes that only few results from innovation contests finally reach the market and moreover become viable services (e.g. Hjalmarsson et al. 2014). By investigating barriers that participants encounter after the contest, we argue that additional understanding can be developed about how contests can support the establishment of sustainable open data markets and how contest can propel third-party developers to finalize open data services with high level of viability. Such understanding will widen the comprehension of the function innovation contests have in open data service development and how such open processes can be designed, operated and evaluated.

2.3 Innovation barriers

An often-perceived problem is that organizations as well as societies are insufficiently innovative. This includes difficulties in generating innovative ideas, problems in transforming initial innovations into products, and resistance to adopting innovations (Hadjimanolis 2003). One approach to investigating these challenges to innovation is to identify innovation barriers, i.e. constraints or factors that inhibit innovation, as defined by Piatier (1984). Barriers and success factors can often be seen as two sides of the same coin, e.g. when the presence of a resource counts as a success factor, while its ab-

sence is seen as a barrier. There exists a huge literature on innovation barriers as well as the related notion of success factors for innovation (e.g. Lee et al., 2010, Becker and Dietz 2004).

Barriers have been studied at different levels of innovation, from the individual to the firm, sector and country level (King 1990). In this paper we focus on the firm level in order to concentrate on the teams of third-party developers participating in digital innovation contests. From a static point of view, barriers are antecedents to innovation, but Hadjimanolis (2003) argues that the nature of barriers is dynamic, evolutionary and complementary and that their effects on innovation are combined. For example, certain barriers act at different phases of the innovation process and some barriers intermediate the effects of other barriers. The impact of a barrier is determined by at which stage or phase of innovation it acts and the mechanism of action (Hadjimanolis 2003). Therefore we expect barriers that constrain open data service development to vary over time in importance and to affect each other, so that if one barrier were overcome then other barriers would appear.

2.4 Innovation barriers to open data service development

Hjalmarsson et al. (2014) investigate the impact of innovation barriers on open data service development as perceived by developers adjacent to innovation contests when transforming initial innovations to viable services. The investigation resulted in a list of eighteen innovation barriers grouped in six categories, c.f. table 1.

Barrier		Meaning
Finance	Lack of time or money to prepare market entry	Time and money are scarce resources to any business and an obvious challenge for teams transforming early innovations to products.
	Lack of external funding	The team has difficulties in attracting external financing, such as venture capital or government innovation funds.
Knowledge	Lack of marketing competence and market information	The team does not possess market knowledge for the developed service nor the skills to develop market understanding.
	Lack of technical competence and innovation experience	No previous experience of innovation and a shortage of necessary technical expertise in the team.
	Difficulties finding competent team members	A shortage of candidates to fill competence gaps within the team.
Market	Weak value offering	The customer benefits offered by the service developed by the participating team are unclear or poorly articulated.
	Multifaceted market conditions and uncertain product demand	The market is unclear and the demand for the service is uncertain.
	High market competition and saturation	A high level of competition in a market where the only way to gain market share is through someone else losing a similar share.
	Viable product features uncertainty	To know when a product is sufficiently prepared for market entry, i.e. "least viable product" incl. most vital functions and features.
Organization	Lack of partner co-operation for technical development	Difficulties in establishing partnerships for the development of the service, or parts of it.
	Difficulties establishing licenses for APIs and other services	Challenges in establishing the agreements with suppliers for the use of the necessary data, protocols and services.
	Lack of partner co-operation for technical tests	Difficulties in including external partners such as data or service providers for the team to test their own service thoroughly.
	Lack of partner co-operation for knowledge transfer	The need to have access to information from within a partner organization.
Regulation	Inefficient intellectual property processes	The team has difficulties in protecting the rights to their service innovation.
	Hindering industry structures	The viability of the team's services was contingent on finding creative ways of dealing with e.g. licensing, regulations or industry agreements.
Technology	Varieties of smartphones requiring unique service development	The service has to be developed and maintained in several versions for different types of smartphones.
	Difficulties in reaching adequate technical quality in the service	Challenges related to technical development and the ability to design a service of high technical quality
	Limitations in existing service-dependent platforms	Deficiencies and lack of functionality in, for example, operating systems for mobile phones or web-browsers that the team depends on.

Table 1. Innovation barriers to open data service development (Hjalmarsson et al., 2014).

The innovation barriers included were partly derived by consolidating barriers found in literature (Atuahene-Gima, 1996, Becker and Dietz, 2004, Bond and Houston, 2003, D'Este et al., 2012, Danne-

els and Kleinschmidtb, 2001, Gilsing and Nooteboom, 2006, Greis et al., 1995, Hadjimanolis, 1999, Hall and Bagchi-Sen, 2002, Kaufmann and Tödtling, 2002, Lee et al., 2010, Leiponen, 2006, Van de Vrande et al, 2009, Van der Panne, 2002, Van Riel et al, 2004) and partly identified during an empirical investigation of the participants in innovation contests. The longitudinal survey presented in this paper use this list of innovation barriers as a point of departure. The aim is to within the context of open data service development better understand the dynamic nature of innovation barriers and how barriers vary in importance over time, as Hadjimanolis (2003) argue.

3 Case Description

The case in this paper is the service deployment process after the digital innovation contest Travelhack 2013. The rationale for selecting Travelhack 2013 as case is that its temporal disposition allowed an excellent opportunity to access and over time study innovation barriers facing third-party developers after innovation contests. The contest was organized by three organizations: SL, the public transportation authority (PTA) in Stockholm, Samtrafiken, a service provider jointly owned by PTAs in Sweden, and the research institute Viktoria Swedish ICT. The main goal was to attract the best developers in Sweden to design and develop novel digital services based on open data that support travelers to use public transportation, and through this increase the attractiveness of public transportation and open data development in Sweden. PTAs in Sweden had used innovation contests previously for this purpose and one successful result from previous contests is "NeverLate - traffic assistant" – a digital service that had reached market entry and integrates traffic and calendar date for a substantial installed base. Travelhack 2013 began in January 2013 and was concluded with a final phase three months later. Out of a total of 58 proposals, 25 teams were invited to the final, which was organized as a 24-hour Hackathon, and eventually 21 teams competed in the final. Their contributions are described in table 2.

Team	Description of contest contributions
Ticket app	Collects, filters and provides public transportation information and create a "smart" ticket for end users
LoCal	The service will connect the end users' calendar to his/her trip door-to-door
GuideMyDay	The service will provide one or half-a-day city tours to end users based on multiple open data sources
Trafficity	A web based service that will collect and mash all public transportation alternatives available
narmaste.se	Combines public transport data with data about local shops and organizations at the destination
Bästtrafik	The service create a digital suggestion box where end users can suggest improved ideas
PRISKoll	The service will enable end users to receive a complete view of different ticket prices door-to-door
Reskänsla	This service will enable end users to feedback issues about the trip the public transport authority (PTA)
CityFix	The service will enable end users to report improvement needs and ideas to PTAs
KadARbra	The service use augmented reality to improve end users' intake of public transport information at a stop
Min skylt	The service will provide the end user with his/her own public transport information dashboard
Kultursafari	The service provides information in real time about the places that the traveller passes during his/her trip
Soundscape	The service will provide a tailored sound experience to the end users when using public transportation
Trip Mashup	The service will based on open data from e.g. Spotify tailor a play list with songs for the trip route
Top 10 Picks	The service will list the ten top picks (e.g. restaurants) at the destination
Alltick	The service will enable the end user to be able to pay for a trip by pressing one button only
Resledaren	The service will lower the threshold for cognitive dysfunctional individuals to use public transportation
IRTPTP	Set-up an intermodal (car/public transport modes/bike/walk) door-to-door trip calculator
Hit och dit	The service will support people with disabilities to plan and use public transportation by easy navigation
TravelQuiz	The service challenge end users to do a quiz based on the route travelled with public transportation.
Underart	The service will inform the traveller about the famous art collections in Stockholm's subway

Table 2. Teams and contributions competing in Travelhack 2013

The teams contended in one of three categories, as well as for the overall winners' prize, which was a complimentary trip for the whole team to Disrupt San Francisco in the fall of 2013. At the end of the final a jury evaluated the prototypes developed by the teams, based on four criteria: innovativeness, potential to make an impact, technical feasibility and usefulness. Trip Mashup won the category for making public transport journeys more fun. Ticket app won the category for making public transport trips more efficient and Resledaren won the category making public transportation more accessible to everyone, as well as won the overall winners' prize. The post-contest process targeted in the research presented in this paper span from March 2013 to October 2014.

4 Research Method

The longitudinal survey presented in this paper is anchored in the results from the explorative single case study performed two months after Travelhack 2013 (c.f. Hjalmarsson et al. 2014). This single case study involved an explorative and a confirmatory research phase. The aim of the *exploratory* phase was twofold. First, while the existing literature offered substantial insight into barriers for innovators' market entry, prior research had not been studying innovations developed from innovation contests and hence needed empirical confirmation. Second, as innovation contests are a novel and emerging concept, the chances were that new, previously unnoticed barriers would appear which the first phase aimed to investigate. The first phase generated 15 anticipated barriers that, according to the participants in Travelhack 2013, might affect their effort to transform the contributions to the contest into viable services after the contest. In the second phase, the *confirmatory* phase, these anchored barriers were measured in terms of importance using a Likert scale 1 to 5 (from highest (score 5) to lowest (score 1)) as to what degree they were perceived as a barrier two months after the contest. This step also included open-ended questions to collect data to discover complementary barriers. 19 of the 21 teams participating in the contest final participated in this survey, which resulted in 15 barriers being evaluated and three additional barriers being discovered.

This paper adds a third phase to the research process reported in Hjalmarsson et al. (2014) transforming it into a longitudinal survey. It compares data about perceived barriers from the 2-month survey with data about the innovation barriers perceived by the teams 18 months after the contest. In this third phase, the *comparison* phase, data was collected in two iterations. For the first iteration a semi-structured interview guide was designed with closed-ended questions aiming to collect 1) the status and the current plans in the teams, 2) how much time and effort the teams had invested in development after the contest, and 3) to what degree the 18 barriers from the first survey were perceived as barriers 18 months after the contest, using the same Likert scale 1 to 5 to measure importance, creating base for comparison of results from the first survey. The interview guide was completed with an open-ended exploratory question asking the teams to describe any other barriers not covered by the 18 barriers from the first survey. 17 of the 21 teams from the Travelhack 2013 final participated in the first iteration in the second survey. The teams were contacted by telephone in early October 2014 and the interviews took each 35-45 minutes to complete. After completing the first iteration, the responses to the open-ended question were systemized and analyzed. This exploratory investigation discovered six additional barriers not covered by the initial 18 barriers. A closed-ended interview guide was developed with six questions using the same Likert scale to determine the importance of the six new barriers. The 17 teams were once again contacted at the end of October 2014 to rate the six discovered barriers in terms of importance. All teams providing input in the first iteration also participated in the second iteration of the 18-month survey.

We used descriptive statistics, e.g. arithmetic mean and standard deviation (Balnaves and Caputi 2001), together with the statistical approach effect size to compare barrier importance and analyze differences in perceived barriers 2 and 18 months after the contest. Effect size is a simple way of quantifying the difference between two groups that has many advantages over the use of tests of statistical significance, like hypothesis testing. Effect size highlights the size of the difference rather than confusing this with sample size (Coe 2002). We decided to use effect size instead of hypothesis testing like the t-test as there are at least three problems with hypothesis testing. First, statistical power depends on how big the effect is, and bigger effects are easier to spot. Statistical power is thus affected by sample size. For example bigger sample size investigations are characterized by less sampling error and better approximation of the population. Second, measure of significance is also dependent on sample size. A smaller sample size may lead to loss of important effects and a larger sample may lead to eliciting very small and insignificant effects to turn out to be significant (Field 2013). In our case we have 17 and 19 responses, which is inadequate for running hypothetical testing and generalizing the characteristics of the groups. Third, the strictness in deciding that an effect is significant, like in hypothesis testing, depends on sample size. The nil or null hypothesis is always false because it is based on probability (Cohen 1994, Field and Wright 2006). Furthermore null hypothesis testing does

not tell us about the importance of the effect (Field 2013). To analyze and compare the results from the 2-month survey with the 18-month survey we use mean and median to describe the data (Balnaves and Caputi 2001), and the Cohen's d to calculate the effect size. The interpretation of Cohen's d value is d=0.2 small, d=0.5 medium, and d=0.8 large effect (Field 2013).

5 Longitudinal results

5.1 Discovery of additional innovation barriers

As previously described the first iteration in the 18-month survey included open-ended questions to capture innovation barriers not covered by the barriers anchored in the 2-month survey. Four of the 17 teams reported insights leading to the discovery of six new barriers constraining the transformation of contest contributions to market ready services: *B19 Lack of quality in used open data; B20 Needed open data sets are missing; B21 Changes in used APIs at short notice; B22 Lack of model to generate revenues to sustain development; B23 Lack of interest within the team to pursue development; B24 Hard to interact with data providers*.

Two of the discovered barriers are linked to perceived flaws in open data needed. One of the respondents indicating *B19 lack of quality in used open data* gave as an example that there were "*discrepancies in how specific objects were identified in different open data streams*" which made it difficult or impossible to match objects, e.g. about a station or a bus line, using data from different data streams. Two of the developers also mentioned that their services in order to fully function required data sets that was not currently provided: *B20 Needed data set are missing*. This challenge inhibited one of the teams in pursuing development and had forced the team to pause the work. The other team had created workarounds to cope with the lack of data. This in turn reduced, according to the developer, the end users' value of the service. This team also described *B21 Changes in used APIs at short notice*. As team resources for development are limited, changes by the data provider in existing APIs, required teams to adjust or rebuild their services for them to continue to work. The barrier was not connected to the change per se but instead *"that the data provider could provide notice in advance so we can plan for adaptation or design differently"* When changes are made at short notice developers become frustrated that they have to remake code that would have been developed differently if they had known about the changes far ahead of the change.

One of the teams, that had made most progress after the contest, described barrier *B22 lack of model for how to generate revenues to maintain the service,* i.e. finding ways to create financial resources to be able to manage after market entry, for example, changes in APIs used by the service, to provide support to users or to manage bugs that users report back to the team: *"Our assumption is that* [name of the service] *must be free for the intended user group... if not we will not get a sufficient user group. However if we do not receive any revenue from the service then we cannot prioritize maintaining it which will hamper its success…we spend a lot of time thinking and discussing how to create a revenue flow from the service when it is launched."*

Another team that stopped development already three months after the contest described a fifth barrier *B23 Lack of interest within the team in pursuing development. "*[W]*e planned to continue development and everyone was on doing this…however then summer came and I guess the motivation just faded away. Nothing really pushed us to continue…and honestly before your call I have not really given* [name of the service] *much thought. Sad, because it was a good idea"* The final barrier discovered is labelled *B24 Hard to interact with data providers*. Three of the teams indicate that it is hard to connect to open data providers in order to feed back quality issues, or request new complimentary open data sets or collaboration in the development process: "[The name of the service] *is not simple, it is an advanced end user service that requires other types of data which we know or expect are in their systems and APIs. Today the only way to feed back requests are through non-regular meet-ups, and they are ok, but it is not the same as a "hotline" to the supplier."*

5.2 Team status and development plans

Table 3 provides a summary of the status and plans 18 months after the contest. At this stage only four teams stated that they planned to finalize their contribution to be launched for end users. Of these four,

three were actively developing at the time of the survey and one had paused development, awaiting changes in the industry structure and the release of additional open data.

Team status and plans 18 months after the contest	No. of Teams	Active Teams	Type of Team			
			Corpo-rate	Aca-demic	Commu-nity	Mixed
Complete the open data service without collaboration	2	(2)	0	0	1(1)	1(1)
Complete the open data service in collaboration with partner(s)	2	(1)	1(1)	0	0	1
Complete it by selling the prototype to an external party	0	(0)	0	0	0	0
Will not finalise the digital service	7	(0)	2	2	3	0
Have launched the service without reaching end user impact	5	(0)	1	0	4	0
Made available as open source project	1	(0)	0	0	1	0
Total number of teams participating in the 18-month survey	17	(3)	4(1)	2	9(1)	2(1)

Table 3. Team status and development plans 18 months after the contest.

Eight of the teams reported that they had decided to halt development. Of these teams, seven stated that development merely faded out. One of these groups decided, when they noticed that their motivation disappeared, to end development and publish their project as open source on GitHub for other third-party developers to use in their development. Five teams reported that they had completed and launched their service on the market. None of these teams reported that they had reached a significant impact. A review of Google Play shows that two of the services have reached between 100 and 500 downloads each with mediocre reviews from end users.

5.3 Perceived innovation barriers to open data service development

Table 4 displays 1) the results from the close-ended survey 2 months after the contest, and 2) the results of the close-ended survey of perceived barriers 18 months after the contest. The table also 3) displays changes in barrier importance between the surveys using arithmetic mean as base.

Barriers to Open Data Service Development	Post-contest Evaluation Results				
	2-month Survey		18-month Survey		Barrier Importance
	Mean	St. Dev.	Mean	St. Dev.	
B3. Lack of time or money to prepare market entry	4.32	0.57	4.00	1.56	↘
B22. Lack of model to generate revenues to sustain the service	N/A	N/A	4.00	1.09	↑
B23. Lack of interest within the team to pursue development	N/A	N/A	3.82	1.44	↑
B11. Weak value offering	3.21	1.44	3.71	1.39	↗
B20. Needed open data sets are missing	N/A	N/A	3.53	1.66	↑
B5. Lack of external funding	2.11	1.37	3.53	1.62	↗
B6. Multifaceted market conditions and uncertain product demand	2.84	1.39	3.35	1.22	↗
B19. Lack of quality in used open data	N/A	N/A	3.29	1.44	↑
B14. Difficulties in reaching adequate technical quality in the service	1.89	0.97	3.18	1.59	↗
B21. Changes in used APIs at short notice	N/A	N/A	3.12	1.30	↑
B24. Hard to interact with data providers	N/A	N/A	3.12	1.44	↑
B18. Hindering industry structures	N/A	N/A	3.12	1.30	↑
B10. Lack of partner co-operation for technical development	3	1.44	3.06	1.47	→
B7. Lack of marketing competence and market information	3.26	1.25	3.00	1.39	↘
B4. High market competition and saturation	1.84	1.31	2.88	1.54	↗
B17. Viable product features uncertainty	N/A	N/A	2.53	1.45	↑
B15. Lack of partner co-operation for technical tests	1.79	0.89	2.24	1.45	↗
B13. Varieties of smartphones requiring unique service development	2.42	1.39	2.12	1.41	↘
B12. Limitations in existing service-dependent platforms	1.53	0.99	1.94	1.18	↗
B9. Difficulties establishing licenses for APIs and other services	1.95	0.73	1.76	1.24	↘
B16. Lack of partner co-operation for knowledge transfer	N/A	N/A	1.76	1.29	↑
B1. Lack of technical competence and innovation experience	1.84	1.09	1.41	0.79	↘
B2. Difficulties finding competent team members	1.32	0.73	1.29	0.68	→
B8. Inefficient intellectual property processes	2	1.49	1.18	0.73	↘

Table 4. Perceived barriers in order of importance from highest (score 5) to lowest (score 1).

Two barriers score highest in the 18-month survey: *B3. lack of time or money to prepare market entry* and *B22. lack of model to generate revenues to sustain development* (mean 4.00, std. dev. 1.56 and 1.09 respectively), while *B8 Inefficient intellectual property processes* (mean 1.18, std. dev. 0.73)

scores lowest. When compared, B3 scores highest in both surveys, however it drops in importance using mean as base for comparison, yet B3 retain its position as the barrier inflicting the greatest impact on teams after an innovation contest. B3 is closely followed by *B22. Lack of model to generate revenues to sustain the service,* a barrier that show that teams after a contest face the challenge to create conditions to maintain the service beyond transforming it to a finalized and launched service, e.g. the financial means to correct bugs, fund improvements and sustain operations. B22 was not perceived as a barrier in the 2-month survey, but it has surfaced as one of the most important barriers at the time of the 18-month survey. These two highest scoring barriers are accompanied by an organizational barrier *B23. Lack of interest within the team to pursue development.* Teams are significantly hampered by reduced intrinsic motivation to continue the development of the open data services. One explanation for this can be that when the effects of other hindering barriers strike these mainly non-corporate teams, their impact drains the motivation to pursue development, and the team dissolves and loses capability. Both B22 and B23 are novel barriers not perceived in the 2-month survey. One explanation why these barriers appears first in 18-month survey is that it is only when momentum of development has reached to a certain level that mainly intrinsic motivational factors cannot solely drive implementation of the open data services.

These three top scoring barriers are followed in importance by *B11. Weak value offering*, *B20. Needed open data sets are missing* and *B5. Lack of external funding*. These barriers receive lower scores than the top three; nonetheless, they all have a relatively large spread in terms of answers (B11 std. dev. 1.39. B20 std. dev. 1.62, B5 std. dev. 1.66) and are thus still important barriers to explore and understand. B11 drops in importance at the 18-month survey. This can be explained by the fact that a minority of teams have overcome B11 and B3, and have as such created a value offering that has potential to attract end users and funding. Still for a majority of the teams B11 is still a barrier that they have not managed. The appearance of B20 indicates that when the teams have created a momentum in implementation they eventually reach an understanding of what can be done with the provided data and what data is actually needed to fully complete the contest contribution to a market ready service. B20 indicates a gap between the data needed by the teams to implement the open data service and the data available on the open data market. Somewhat surprising B20 is not reported in the 2-month survey; instead it has surfaced when the teams have struggled to build up development momentum.

Using mean as base, the evaluation shows that B3, B22, B23, B11, B20 and B5 are perceived as the most important barriers to efficient open data service development 18 months after the contest. When we apply the statistical method of effect size to compare the rating of the barriers we can state a difference in the innovation barriers perceived between the two surveys. Effect size was calculated using Cohen's d (Field & Wright 2006; Field 2013) and the overall effect is medium to large, d=0.51 between the 2-month and 18-month surveys. In order to manage the difference in number of measured barriers between the 2 and 18-month survey we used a pulled standard deviation of the two groups. As illustrated in table 4 there were 15 innovation barriers measured in the 2-month survey and 24 innovation barriers measured in the 18-months survey. Nine of these innovation barriers were discovered in the period between the two evaluations.

5.4 Comparison of team status and development plans

When comparing team status and development plans, it becomes evident that the degree of teams that actively plan to finalize their contest contribution has decreased significantly between the two surveys, see table 5.

In the 18-month survey the percentage has risen to 40% in terms of teams that have dropped their plans to complete the open data service. Examining this group closer shows that the average length of development performed by these teams after the contest is less than one month; i.e. development in these teams never really reactivated after the contest although the majority had the ambition to do so two months after the contest. In the 18-month survey 34% of the teams stated that they have finalized the service. Of these 86% stated that they have launched the service on a market. However none of these services have, according to the teams, reached a significant end user base after launch.

Team Status and Development Plans	2-month	18-month
Teams that have finalized the open data service	0%	34%
• *...who has launched it as an end user service and reached a significant user base*	*0%*	*0%*
• *...who has launched it as an end user service without reaching a significant user base*	*0%*	*86%*
• *...who has made it available as open source*	*0%*	*14%*
Active teams that intend to finalize the open data service	83%	26%
• *...who is on-going with development*	*38%*	*75%*
• *...who has paused development*	*62%*	*25%*
Teams that will not finalize an open data service	17%	40%

Table 5. Comparison of team status and plans 2 versus 18 months after the contest

26% of the teams stated that they actively plan to finalize the contest contribution and make it market ready. Of these, 75% are active 18 months after the contest and 25% have paused the development, mainly due to hindering industry structures and a lack of needed open data. If and when these barriers can be overcome the development will, according to the respondents, be re-activated with the goal to prepare a market introduction. On average the teams in this category have continued development 13 months after the contest and spent 7.6 man-months on activities connected to the transformation of the contest contribution to market ready services.

5.5 Comparison of perceived innovation barriers based on team progress

In order to investigate if there are any differences in perceived barriers amongst the teams, the results of the 18-month survey have been analysed based on team progress reported by the teams; i.e. number of development months they have continued after the contest. This comparison is presented in table 6.

Barriers to Open Data Service Development	Comparison of barrier importance based on number of development months after the contest		
	10 to 18 Months	2 to 9 Months	1 Month or Less
B3. Lack of time or money to prepare market entry	1.67	4.57	4.43
B22. Lack of model to generate revenues to sustain the service	4.33	4.14	3.71
B23. Lack of interest within the team to pursue development	1.67	4.00	4.57
B11. Weak value offering	3.00	3.71	4.00
B5. Lack of external funding	3.67	3.86	3.14
B20. Needed open data sets missing	5.00	2.71	3.71
B6. Multifaceted market conditions and uncertain product demand	3.33	3.14	3.57
B19. Lack of quality in used open data	4.33	3.43	2.71
B14. Difficulties in reaching adequate technical quality in the service	4.67	3.29	2.43
B18. Hindering industry structures	4.33	3.14	2.57
B21. Changes in used APIs at short notice	4.33	2.71	3.00
B24. Hard to interact with data providers	3.00	3.29	3.00
B10. Lack of partner co-operation for technical development	3.33	3.00	3.00
B7. Lack of marketing competence and market information	2.00	3.57	2.86
B4. High market competition and saturation	3.33	2.71	2.86
B17. Viable product features uncertainty	2.33	2.29	2.86
B15. Lack of partner co-operation for technical tests	3.33	2.57	1.43
B13. Varieties of smartphones requiring unique service development	1.00	2.14	2.57
B12. Limitations in existing service-dependent platforms	2.00	2.00	1.86
B9. Difficulties establishing licenses for APIs and other services	1.00	1.71	2.14
B16. Lack of partner co-operation for knowledge transfer	3.00	2.00	1.00
B1. Lack of technical competence and innovation experience	1.33	1.71	1.14
B2. Difficulties in finding competent team members	1.00	1.29	1.43
B8. Inefficient intellectual property processes	1.00	1.43	1.00

Table 6. Comparison of perceived barriers in order of importance based on team progress

The teams were divided in three groups based on an overall evaluation of three criteria: development effort after the contest, team status and future plans. 18% have continued more than 9 months after the contest and report that they have momentum in their development. 41% reports that they have continued development anywhere between 2 to 9 months after the contest, and an equal percentage reports that development continued only 1 month or even less after the contest.

The innovation barrier that scores highest in the overall analysis (see section 5.3, table 4), *B3. Lack of time or money,* is perceived as a significant barrier for those teams that have not passed 9-month interval after the contest. For teams that have continued development 2 to 9 months the mean for this barrier is 4.57, and for teams that have made progress only 1 month or less the mean is 4.43. By contrast, B3 seems not be significant for teams who have continued development for 10 to 18 months. This is an indication that these teams have been able to manage this hindrance either by pooling resources internally or attracting external funding. Similar tendencies exist when comparing *B23. Lack of interest within the team to pursue development* and *B11. Weak value offering*. For teams that have passed the 9-month interval B23 scores low in importance. This indicates that there is not a current challenge within these teams to motivate continuation of development. By contrast, for teams that have not passed this interval B23 significantly hampers their effort. Also, teams that have passed the 9-month interval indicate that B11. Weak value offering is not significantly inhibiting their progress. This indicate that teams that have past the 9-month interval have been able to shape their open data service not only as a coherent technical solution but also have designed a value offer that is attractive to end-users and/or external partners and funders.

Teams that have passed the 9-month interval score certain barriers higher that the other teams score lower. These barriers are on one hand connected to open data (B20, B19, B21) and technical quality (B14) and on the other hand connected to existing hindering industry structures (B18) prevent market entry. All teams passed the 9-month interval indicate that missing and low quality in open data required for their service hamper their development activities. However, when examining the status in these teams, only one team has paused their development; all other teams are active. This indicates that additional or quality improved open data can strengthen the attractiveness and the value offering in the services being developed by these teams; however the use of workarounds or lowering priority on requirements solves the urgent challenge that missing or low quality data creates. The dependency on open data is also visualised in B21 as changes at short notice in used APIs imposes negative effects on team progress. These barriers also impose problems for some of the teams that have not passed the 9-month interval, however the majority of these teams do not score these barriers high which is an indication that they have not yet reached such momentum that these barriers surfaced.

One significant difference is discovered in the comparison. In the 2-month survey barrier *B14. Difficulties in reaching adequate technical quality in the service* only reaches a mean of 1.89, but in the 18-month survey the mean increases to 3.18 (cf. section 5.3, table 4). In the comparison based on team progress this barrier is the second highest scoring barrier with a mean of 4.67 for teams *that have passed* the 9-month interval (cf. table 6). One tentative explanation for this is that teams generally in close proximity to the contest downplay technical challenges connected to their service, either because they have to focus on managing barriers connected to time and prioritization, or because they are not fully aware of the challenges ahead to successfully complete an attractive and technically feasible service. It instead becomes evident for teams making progress preparing market entry. This might also be a tentative explanation for why the barrier *B18. hindering industry structures* only surface as an important barrier for teams that have reached a certain level of progress. It requires plenty of efforts to understand the context in which the service should operate; e.g. current regulations for payment. Teams struggling to re-activate after the contest might downplay or not yet recognize this barrier.

One of the innovation barriers scores high regardless of interval: *B22. Lack of model to generate revenues to sustain service*. Our interpretation is that all teams struggle with the challenge to get a business model in place that yields continuous operating returns so that they in some form can retain the service when it has been released on the market. The teams that have passed the 9-month interval seem to have mobilized resources that enable them to prepare market entry; e.g. low scores on B3 and B23. However they too struggle with how to create a flow of reliable income that enables them to sustain the service after it is launched on a market.

Seven of the barriers score low regardless of team progress. The collected data does not provide any insights into whether this is due to the fact that these barriers have had an impact in other phases prior or during the contest, or if it is that amongst these barriers exist those that will become important when

teams have entered a launching, maintaining or up-scaling phase. We perceive them as barriers with less importance in transforming contest contributions into market ready open data services.

In table 7 a comparison is done using SPSS to calculate effect size to measure the differences among the teams. The groups are labelled as group 1 (g1) teams that have worked 10 months or more, group 2 (g2) teams active 2-9 months and group 3 (g3) teams active 1 month or less. Since these three groups are independent, pooled standard deviation was used as formula (Field, 2013). The effect size was then calculated using the Cohen's d.

Group		N – rated barriers	Mean	Std. Deviation
Means	g1	24	2.83	1.30
	g2	24	2.85	.90
Sp = 1.12, and Mean Difference = 0.02, and **d= 0.02**				
Means	g1	24	2.83	1.30
	g3	24	2.71	1.02
Sp = 1.17, and X1-X3= 0.12, and **d= 0.11**				
Means	g2	24	2.85	.90
	g3	24	2.71	1.02
Sp = 0.96, and X1-X3= 0.14, and **d= 0.15**				

Table 7. Comparison of the difference between perceived innovation barriers using effect size

The results show that g1 and g2 perceived innovation barriers in a similar way. There is no effect when the groups are compared, Cohen's d=0.02. But when g3 is compared to the other two groups there is an effect, g1 compared to g3, Cohen's d=0.11 and g2 compared to g3, Cohen's d=0.15. Those teams that were active for a longer period after the competition perceive barriers differently from the teams less active after the competition is concluded. The teams that were active for one or less than one month (g3) were affected by some of the barriers and decided to not complete their services. In addition, there are barriers that differentiate g3 more from g1 and g2, for example: *B23. Lack of interest to pursue development*; *B3. Lack of time or money to prepare market entry*; *B11. Weak value offering* and *B6. Multifaceted market conditions and uncertain demand*

Finally since the survey was conducted at the same time for all of the teams, there are expected variations in the rating. Teams who have been active longer after the contest have been able to cope with some of the barriers, and the ratings after they have encountered them seem to reflect the impact of the barriers on their activities. On the other hand teams that were less active after the competition could have rated innovation barriers differently, based on their assumptions of their perceptions. Also, these barriers can be assumed to be the reason for them stopping development after the contest.

6 Discussion

The results from this longitudinal survey show that third-party developers face innovation barriers in at least three phases after an innovation contest. We denote these phases *activation*, *building development momentum* and *preparing market entry*. In the first phase, labelled *activation*, adjacent to the contest, the developers mainly struggle to mobilise to free time or financial resources to be able to prioritize continued development of the contest contribution. At this stage, yet of less impact, developers also struggle with understanding the market demands that intended customers have on future open data services, and crafting a value offering to make the service attractive for stakeholders.

Those developers that are able to activate development and thus pass the activation phase enter a second phase where *development momentum* needs to be built. The study indicates that developers that are able to retain a focus on the contribution from the contest at least two months after the contest have a good chance of entering this second phase. The barriers developers now face are likewise lack of time and resources, and thus the means to increase momentum for development. Moreover, if needed, but not acquired, lack of external funding also hampers developers at this stage, as well as a lack of an operative revenue model to generate resources for sustaining the service after finalization, which seems to constrain developers throughout the process. If developers are able to make progress in development, other barriers also surface during this second phase. Lack of quality in service-contingent

open data and challenges to ensure adequate quality in the service increases in importance for developers during this phase. Developers also have an increased need now to interact with data providers to request data and receive support, and also a general need to understand customers' need of services.

Using the result of the longitudinal survey as base, we argue that if during the two first phases, *activation* and *building development momentum*, barriers such as lack of time or money are not managed, then interest within the team will disappear and service development will stop. As a consequence, these then semi-completed open data services never will enter the market, or will reach the market prematurely, with insufficient quality to make a significant impact. We believe that these consequences have negative impact in the creation of sustainable open data markets. By contrast, if development momentum is established the survey shows that developers enter what can be defined as a third phase labelled *preparing market entry*. This phase is characterised by a strong focus on assuring the quality of the features selected for the product to be launched. As the momentum within these teams is high, there are little motivational barriers constraining development and resources to prioritize completion of the service is not lacking for developers at this stage. Instead developers struggle with 1) external technological barriers, e.g. missing data to reach the overall goal with the service, lack of quality in open data needed, hindering industry structures, or changes in used APIs at short notice, as well as 2) internal technical barriers, e.g. difficulties in reaching adequate quality in the service being finalized, and lack of partner co-operation for tests or knowledge transfers. In order to strengthen the sustainability of open data markets, external support to teams should focus on these barriers at this stage.

7 Conclusions and Suggestions for Future Research

Lindman et al. (2013) argue based on a literature review that there exists a lack of understanding of open data services and especially how open data markets are created and sustained. The primary function for third-party developers is to provide open data services on the open data market that leads to valuable digital services for consumers. In this paper we have addressed the question *what innovation barriers constrains third-party developers in different phases when performing open data service development after innovation contests*? The longitudinal survey of barriers inhibiting developers transforming prototypes to market-ready services have yielded 24 innovation barriers in relation to finance, knowledge, market, organization, regulation and technology. These barriers have been measured in terms of importance and positioned in relation to three post-contest phases: activation, building development momentum and preparing market entry. External support for teams to manage barriers must be mindfully provided based on knowledge regarding barrier occurrence and process awareness.

In section 6 we discussed how barriers constrain developers in these phases, and it is somewhat surprising that technological barriers seem to have significant impact first when developers have built development momentum and are preparing for market entry. This indicates a need to stimulate developers to early on in the process systematically assess available data sources in order to determine the characteristics of the data at hand (Hjalmarsson et al. 2015). Technological barriers to open data development are not new and have been previously reported (e.g. Janssen et al. 2012, Zuiderwijk and Janssen 2014). This longitudinal study complements these findings by highlighting that such challenges surface late in the development effort, and widens the focus beyond merely technological barriers as it adds novel barriers in non-technological categories not previously conceptualised. This study shows that within this class some barriers must be coped early on to activate development. The results support that innovation barriers are dynamic and that their importance varies at different phases of the innovation process (Hadjimanolis 2003).

For future research we intend to analyse these characteristics more profoundly using alternative methods, such as longitudinal qualitative research, to better understand the mechanisms of barriers and also to compensate for shortcomings of the methods used in this survey. By doing so we intend to contribute to the emerging research agenda on open data services with explanatory and action type of theory for how different stakeholders can classify (e.g. level of urgency), address and manage innovation barriers and provide support more effectively prior to and after innovation contests. Moreover a deeper understanding of the mechanisms of innovation barriers may provide new theory for balancing external and internal resources in open innovation (Dahlander et al. 2010).

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