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Managing the innovation space

How firms can shape collaboration practices in the context of innovation communities

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ABSTRACT

The goal of this paper is to analyze the innovation space where firms and free collaborators meet. We considered it from the point of view of the intermediation function theorized in the open innovation paradigm and focused on the decisions firms can take in order to shape the in- and out-knowledge-flow for their own goals. Building on the case study of a player in the automotive industry, we examined how the structure and governance of interactions as well as the activity of community managers can influence the final output of collaborative innovation practices. Using network-, statistical and content analysis we argued that different strategies address different motivations and thus generate specific forms of engagement which could be relevant in specific phases of the innovation process.

KEYWORDS

Open innovation, Innovation contest community, Open source hardware, innovation management, network analysis

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1. INTRODUCTION

Facing an era of radical, disruptive, risky and costly innovations, firms in the automotive industry are confronted with the need to look outside their own boundaries to increase productivity (Ili et al. 2010). Under those conditions, collaborations with external stakeholders become necessary for a firm in order to handle complex technological problems (Dougherty, 2017; Agogué et al. 2013). As theorized in the open innovation paradigm, establishing collaborative practices implies deep organizational changes, and particularly the definition of an agent in charge of the intermediation function, which regulates the in- and out-knowledge-flow (Chesbrough et al., 2006, 10, Gassmann et al. 2010, 216). From a spatial perspective, this intermediation function inhabits a *space in-between* where collaborators met among themselves and with the firm. This task is not entirely performed within the firm but is still under its sphere of influence and implies therefore a dynamic adjustment to the needs and inclinations of collaborators. The goal of this paper is to understand how the intermediation function works in practice and how it shapes the innovation space at the boundaries of firms. For this purpose, we will adopt a practice perspective that focuses on dynamics and relations (Feldman & Ornilowski 2011) and explore them through social network and content analysis. Moving from the case of an emerging player in the automotive sector, the firm Local Motors, we will observe how practices are constituted and reconstituted through the daily interactions between firm and collaborators (Corradi et al., 2010).

The analysis of this innovation space illustrates how firms define the trade-off between openness and closeness in order to create a lively and fruitful collaboration space (Pisano & Verganti, 2008). Following our analysis, we propose three major findings relevant to the management of collaborative innovation practices. Firstly, we find that in-community interactions correlate positively with the output of the proposal. It means that the creation of a lively community will increase the quality of contributions and that contemporary, high quality submissions have a positive effect on the liveliness of the community. This correlation poses the question how to get this mutually reinforcing mechanism to start. In the case we analyzed, the firm opted for a long-term investment in community building that aims to foster user commitment to the group. Secondly, we found that an interaction format that addresses extrinsic motivational drivers like career concerns and promise a monetary reward is more able to engage collaborators. Nevertheless we could distinguish two different types of engagement: the competitive environment of an innovation contest motivates users to explore and interact with competitive proposals; by contrast the classical open-source approach, which relies on a strong modularity and labor division, promotes a deeper commitment, where users engage in a lively manner on individual discussions relevant to them. Thirdly, we investigated the governance techniques adopted by the community managers—the agents in charge of the intermediation function. Our analysis suggests that in order to successfully manage the innovation process in a highly informal and fluid space, such as an online community, community managers must develop a "dynamic capability" (Teece et al. 1997) to continuously adapt the governance technique to a non-homogenous and changing environment.

The structure of this paper is as follows: We will first (2.1) set a conceptual framework to categorize the open innovation processes in the industry where Local Motors is active which is the automotive sector. Following this taxonomy, (2.2) we will present the case of Local Motors and identify its peculiarities. Thereafter we will (3) develop our hypothesis. Subsequently, we will describe our (4.1) methodology and explain the composition of our data sample, (4.2) the way we modelled the data, as well as (4.3) how we investigated Local Motors' governance approach. Finally, (5) we will test our hypothesis, (6) discuss the most relevant findings, and consider limitations as well as future research possibilities.

2. COLLABORATION AND CO-CREATION PRACTICES IN THE AUTOMOTIVE INDUSTRY

The first step in order to investigate co-creation practices in the automotive sector is to identify (2.1) current activities in the industry and to highlight their peculiarities as well as best practices. Given this background, we will specifically consider the (2.2) case of Local Motors and describe the different phases of the development of the self-driven bus *Olli*.

2.1 A framework for innovation practices in the automotive industry

In the following, we will categorize open innovation and open source activities in the automotive sector based on the taxonomy, proposed by Pisano and Verganti, which focuses on the particular balance between open and closed participation, as well as between hierarchical and flat governance. The main advantage of this framework lies in the actionable insights it delivers about the particular strategic trade-offs between openness and closeness that a firm should aim to implement. It is therefore particularly fruitful to investigate the collaboration space and the intermediation function (Pisano & Verganti, 2008). Nonetheless the preliminary question that should be posed is, whether the success of open source software communities (OSSC) and peer-based collaboration practices could be reproduced for open source hardware (OSH) activities and, specifically in our case, in the automotive sector (Lerner & Tirole, 2002, 230). Lerner and Tirole argue, from a theoretical point of view, that the basis to build a productive open source hardware community (OSHC) could be missing, since "users are numerous and rather unsophisticated, and so deliver few services of peer recognition and ego gratification" (ebd., 231). Despite the theoretical expectation, on the side of practitioners, a study by the professional services firm PwC stated in 2013 that co-creation practices are emerging as a mainstream method of collaboration and idea generation in the automotive industry (Ostermann et al. 2013).

Since that time, almost all major automotive companies engaged in co-creation and open innovation strategies: Citroën (Marketing week, 2012)—which started already in 2012—and Nissan (Nissan News 2014) engaged their Facebook communities in design challenges; Honda (Honda, 2018) and Ford (Ford, 2018) implemented online-forms where people could submit their own innovative ideas. More recently, Porsche started a challenge where app-developers could experiment with in-browser car emulators as well as with more than 140 APIs in order to create their own innovative in-car-app (Porsche, 2018). Following the taxonomy proposed by Pisano & Verganti (Figure 1), these kinds of innovation practices can be defined as *innovation mall*, that is "a place where a company can post a problem, anyone can propose solutions, and the company chooses the solutions it likes best" (Pisano & Verganti, 2008, 6).

By contrast, two further models suggested by Pisano and Verganti describe collaboration between members in the context of a closed community. An example in the automotive sector is provided by the "Automotive Grade Linux", a "collaborative open source project that is bringing together automakers, suppliers and technology companies to build a Linux-based, open software platform for automotive applications that can serve as the *de facto* industry standard" (AGL, 2018). This kind of collaboration model can be defined as a *consortium*, where "a private group of participants [...] jointly selects problems, decide how to conduct work and choose solutions" (Pisano & Verganti, 2008, 6). A further example is the "Circle Member Group" set up by Daimler Benz where a selected network of experts collaborate occasionally with the R&D department of Daimler for specific tasks relevant to the company (Boutellier et al. 2008, 88). This last innovation model can be defined—following Pisano & Verganti—as an *elite circle* characterized by a closed community with high entry barriers and research questions hierarchically defined by the firm financing the community.

All those three models—the *innovation malls*, the *consortium* and the *elite circle*—are still missing the high dynamics that the combination of open participation and flat governance have been able to reach in the OSSC. Pisano & Verganti define this combination of open participation and flat governance as *innovation community*: "a network where anybody can propose problems, offer solutions, and decide which solutions to use" (Pisano & Verganti, 2008, 6). In the automotive industry there have already been at least two examples of open innovation communities engaged in the development of an open source vehicle: "OSCar" (Müller-Seitz & Reger, 2010) and the "Open Source Green Vehicle" (P2PF Wiki, 2018). Both projects have been interrupted due to lack of coordination and resources (Lee, 2012, 165; Balka, 2011, 70). From these experiences it does not seem possible to combine the complexity of the automotive industry with the dynamics of an *innovation community*. With this in mind we will present Local Motors and concentrate our research on the particular way they shaped the innovation-space at the boundary between firm and contributors.

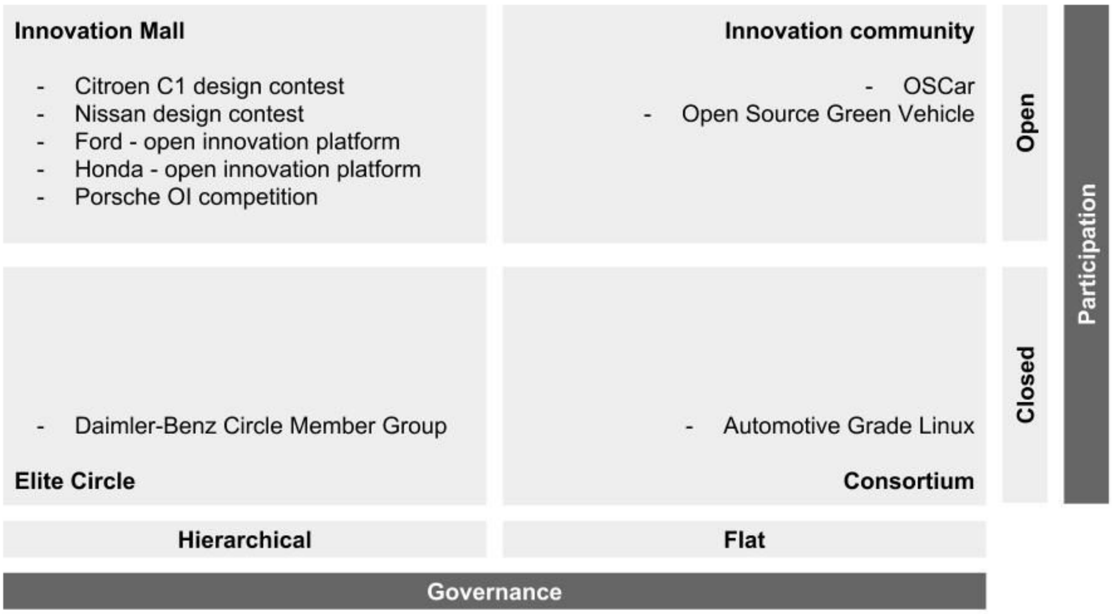

Figure 1: *Taxonomy of open innovation activities in the automotive industry as proposed by Pisano & Verganti (2008).*

2.2 Case study

Local Motors is a US-American company founded in 2007 which, since the beginning, (I) focused on the development of open-source vehicles and (II) attempted to create a lively community of collaborators. In 2016, Local Motors founded a co-creation platform called Launchforth (Ringle, 2016), which has currently—as at March 2018—more than 184 thousand community members (Launchforth, 2018a). In the following, we will examine three projects driven directly by Local Motors. The first one is the "Berlin mobility challenge" which took place between April and June 2015. A challenge is a *call-for-proposals*: community members are invited to submit their own ideas in order to figure out new approaches and—in case of success—are monetarily rewarded. A peculiar feature of the challenges proposed by Local Motors compared to the *innovation malls* started by Porsche, Nissan and Citroën lies in the long-term community building strategy, which aims to offer interaction opportunities to the collaborators. In this particular case, the challenge proposed to the community was designed as an open-ended question and concerned future mobility solutions: "In 2030, what would an urban mobility system look like that is efficient, affordable, safe and sustainable for Berlin?" (Launchforth, 2018b). A total of 91 members actively contributed by submitting ideas or commenting on third party proposals, whereof 3 of them were Local Motors community managers. During the three-month long challenge, 81 proposals were submitted and discussed by the community. By the end of June 2015, 18 projects were selected and awarded in six categories; one of them was defined by a peer-voting-system, while winners for the other 5 categories were selected directly by Local Motors.

Following the first phase of idea-generation, Local Motors decided to develop a follow-up project from one of the submissions to the "Berlin mobility challenge", where a contributor proposed the concept of a self-driving shuttle bus. This second project—called "Olli: self-driving, cognitive electric shuttle"—was not conceived as a challenge, but rather as a task-based project: community managers, but also free collaborators, proposed specific tasks concerning technical issues such as *Thermal management* and *Electrical engineering*, as well as design issues as for instance *Door ingress / egress* and *Universal interface*. 64 Members collaborated actively with 20 Local Motors community managers on 26 tasks (Launchforth, 2018c).

A third project—named "Autonomous for All of Us"—was started in June 2017. During this third phase, which was also conceived as a challenge, Local Motors community managers asked the crowd to provide creative solutions in order "to design the most inclusive experience for Olli riders of all ages and abilities, focusing on one or more of four specific categories of needs" (Launchforth, 2018d). Until the end of the submission phase, 77 proposals were submitted and 114 collaborators actively contributed to the challenge supported by 8 community managers.

These three projects are of particular interest since they exemplify an open innovation process where a company manages a community—starting from the early stage of the initial brainstorming and idea generation, going through the product development at design and engineering level until the final customization—to successfully develop an OSH product in the automotive sector. On the basis of this empirical case we will try to describe the dynamic tension between different organizational and governance principles relevant to the management of collaboration practice.

3. RESEARCH QUESTIONS AND HYPOTHESIS BUILDING

Our research questions address three essential aspects that shape the innovation space. Firstly, we investigate the role that collaborative interactions play in an innovation community. Our investigation of the co-creation activities in the automotive industry highlights that few firms engaged in the long-term goal of creating an innovation community. Therefore, we will ask if long-term community building is a worthy and valuable investment by analyzing the collaborative interactions and their incidence on the innovation outcome. Secondly, we particularly concentrate on the peculiar innovation design of Local Motors. Since the firm opted for a balanced mix of collaboration and competition, we ask whether a competitive or a collaborative environment could motivate the users the most, and how they relate to the different phases of the innovation process. Thirdly, we will focus on the role of community managers as innovation intermediaries. Our analysis will focus on the peculiar balance that they seek to establish between open and community-driven innovation processes, on the one side, and close and firm-driven innovation processes, on the other side.

3.1 Research question 1: The role of interactions in an innovation community

Our first research question relates to the role that interactions play in the the open innovation process (West and Lakhani 2008). As mentioned above, many car manufacturers started *innovation malls* which involved the crowd in *virtual innovation contests*, where a firm posts an innovation-related problem to a population of isolated solvers without any possibility of intra-community interaction (Kathan et al., 2015; Terwiesch & Xu, 2008; Afuah & Tucci, 2012; Boudreau & Lakhani, 2013). Collaborators just disclose their innovations vertically to firms but not horizontally to each other and, consequently, co-creation is just a matter of one-to-many relationships between a firm and individuals. From the point of view of the firm starting the contest, an improvement in the output quality is expected as a result of the *parallel path effect*, which relies on the idea that the availability of a great number of independent approaches will improve the overall innovative performance (Boudreau et al., 2011). This kind of approach should be considered by firms when their problems are highly uncertain or they are interested in maximizing the number of submitted solutions (Ales et al., 2017). Possible limitations due to the increased competition are expected to negatively affect just low or averagely-skilled participant, whereas rivalries are likely to induce higher effort by high-skilled participants who believe they have good chances of winning the challenge (Boudreau et al., 2016).

In the context of our case the question should be if the creation and maintenance of an "innovation contest community" (Kathan et al., 2015), where interactions and proposals are transparent to all collaborators, have a positive effect on the output quality. Following the open source literature, we advance the hypothesis that the communitarian dimension plays a fundamental role and that a collective sense-making process takes place "through the recombination of ideas, voicing of future product wants and convergence towards a common perception of what is valuable" (Dahlander et al., 2008). This collective effort is facilitated by the possibility to discuss, share and improve ideas, as well as to work in a collective environment with like-minded people (Baldwin et al., 2006; Füller et al., 2006; Jawecki et al., 2009). Hence we expect that proposals that have been broadly discussed are more likely to be awared. Moreover we also make the hypothesis that collaborators who take advantage of the communitarian dimension by actively interacting with other community members should have a higher probability of winning the challenge.

Hypothesis 1: (1.1) Proposals that are broadly discussed will be of better quality than those that have been developed in isolation with less support and suggestions from other community members. (1.2) Collaborators who have interacted actively with other members have a higher probability of winning the challenge.

3.2 Research question 2: The design of an innovation community

Our second research question concerns the design of an innovation community and its underlying principles. In the particular case of Local Motors, we want to compare the two different formats that animated the Olli innovation process: the *challenge* approach of the projects "Berlin Mobility Challenge 2030" and "Autonomous for All of Us", which fostered engagement trough competition, and the *task-based* project "Olli: self-driving, cognitive electric shuttle", which aimed to encourage different users to collaborate with the firm on specific tasks in the context of a community.

We suppose that the engagement of users—measured by the number of activities on the platform—depends on the ability of each format to address the motivation of users to collaborate. Since the innovation output—a self-driving shuttle—is almost impossible for individual contributors to build at home, we exclude the possibility that collaborators can be defined as lead users motivated by the benefits related to the final output (von Hippel, 1988). Many scholars argue that since contributors do not necessarily plan to use the design created by the project, they are instead motivated by intrinsic reasons such as the willingness to learn (Ye & Kishida, 2003), creative fun (Lakhani & Wolf, 2005), community obligation and devotion (Hannebauer & Gruhn, 2016) or by a long-term value-informed quest (Von Krogh et al. 2012). Regarding previous open source initiatives in the automotive industry, Müller-Seitz and Reger found in the case of OSCar that idealistic goals, such as providing environmentally friendly mobility solutions, played a crucial role in motivating contributors (Müller-Seitz & Reger, 2010, 630). By contrast, other scholars of OSSC underline the role of extrinsic motivation: (I) career concerns are supposed to play an important role in the decision to contribute to an open source project (Lerner & Tirole, 2002) and (II) paid participation and status motivations have been found to lead to above-average contribution levels (Roberts et al., 2006, 94). Further research that investigates the particular case of firm-driven communities confirms this hypothesis and found that collaborators are particularly sensitive to firm recognition (Jeppesen & Frederiksen, 2006).

Moving from these findings, we formulate the hypothesis that challenges—because they promise an extrinsic reward in the form of a monetary prize and of a reputational gain—should generate higher engagement levels than collaborations on task-based project which rely only on intrinsic motivations. At the same time, if extrinsic values are the most performant driver for engagement, we also expect to find competition-related issues hindering collaboration, since users should be less motivate to contribute to the community and provide feedbacks and suggestions to other contributors.

Hypothesis 2: Challenges—because they promise a monetary reward—should generate higher engagement levels than collaborations on task-based projects, which rely only on intrinsic motivations. At the same time, if extrinsic value are the key driver for engagement, we also expect to find competition-related issues hindering collaboration.

3.3 Research question 3: The intermediation function as played by community managers

The third research question that we want to analyze relates to the governance of a firm-based OSHC. Since community managers interact with stakeholders external to the firm and manage in- and out-knowledge flows, we regard them as key agents of the innovation process who act as intermediaries in an highly uncertain and informal space.

Many empirical studies described how intermediaries operates between firms and institutions acting as bridges (Bessant & Rush, 1995; McEvily & Zaheer, 1999), knowledge brokers (Hargadon & Sutton, 1997; Provan & Human,1999) or as an innovation arena (Ollila & Elmquist, 2011). By contrast, intermediation between firms and consumers, users and free collaborators has been little studied from the point of view of innovation research (Kunne, 2018, 36; Füller et al. 2006). Some scholars have analyzed how community managers have been able to select relevant users from the fan community and engage them in the innovation process. (Sawhney et al. 2006, Jeppesen & Molin, 2003). Nonetheless, we still lack a comprehensive analysis of the intermediation function that community managers play in the open innovation process, even if the support for and empowerment of co-creators have already been recognized as important aspects of a collaboration strategy (Füller et al. 2006). Hence our question asks how community managers coordinate knowledge flows and collaborators in the context of a community-based innovation contest, where shared knowledge, motivations and goals are far less formalized and clear to the participants than in the case of B2B networks.

As suggested by Dahlander and Magnusson, who refer to OSS projects started by firms (2005), the main challenge is to reconcile the rationale for firms—which are primarily driven by economic and technological factors—with the rationale for OSS communities, which are more likely to be driven by social factors than traditional employees (see also West & O'mahony. 2008). In this context, while openness is clearly needed in order to generate ideas, an excessive openness will damage the product innovation, since consumers may not be able to self-organize the solution space (Jeppesen & Molin, 2003).

Following Pisano and Verganti, we expect the intermediation function played by community managers to enable the strategic coordination of collaborations for the sake of the project and hence of the firm (Pisano & Verganti, 2008); nonetheless, the most valuable resource for a firm seeking to establish collaboration practices is the community, which follows a different rationale. From this point of view, the community managers are supposed to combine elements of flat governance, which are typical of open source communities, with hierarchical governance techniques (Pisano & Verganti, 2008). Hierarchical forms of governance are necessary when a firm is able to clearly "define the problem" (ebd.) and has the capabilities as well as the competences to "evaluate proposed solutions" (ebd.). Examples of such governance form are priority setting, as well as the definition of formal requirements, which are needed to enhance knowledge development, management and comparability (Szulanski, 1996). By contrast, flat governance techniques are required when "no single organization has the necessary breadth of perspective or capabilities... to devise and test solutions" (Pisano & Verganti, 2008); this strategy needs to stimulate the commitment of the collaborators to the community in order to improve the quality of debate and the creation process.

The specific balance between hierarchical and flat governance, that Local Motors has been able to define is of particular interest because the only documented case of open source vehicles we could find—the OScar Project—was motivated by the desire to "build the car in a web-based community [...] without a boss […] without hierarchies" (Müller-Seitz & Reger, 2010, 629) but failed a few years later due to organizational issues (Lee, 2012, 165). Summarizing, our first research question concerns the intermediation function played by community managers and their particular form of governance, following the literature we expect that

Hypothesis 3: Community managers act as (3.1) bridges between firms and collaborators as well as between the different collaborators involved in the process in order to create a lively community. To reach that goal they are supposed to (3.2) combine flat governance techniques, which "open up" the knowledge flow, with hierarchical strategies, which regulate knowledge flow and discourage developments in unwanted directions.

4. RESEARCH SETTING

In the following we will describe our dataset and the methodology we adopted. Particularly relevant is the illustration of our network model. For this purpose, we need to legitimate our model design by referring, firstly, to previous works in the vast field of network analysis of open source communities and, secondly, to the peculiarities of the Local Motors community, as described above in our case study (cf. paragraph 2.2.) .

4.1 Data and methods

To empirically investigate our case study, data was collected by the end of December 2017 at a time when all projects already came to an end. We scraped 210 discussion threads[1] and found 275 active members, whereof 250 members were classified as "contributors" and 25 as "community managers". By scraping the platform we collected the following data: username of each contributor involved[2], related project—e.g. "Autonomous for All of Us"—, content and title of each discussion topic—e.g "The Universal Chair". Furthermore, we labeled each discussion topic, first, as "spam" or "not spam" and, second, as "valid" or "not-valid". Discussion topics are "spam", if they were not admitted due to low-quality profiles or because the collaborator was missing the legal age. We didn't consider these contributions for our analysis. By contrast, we still took in account discussion topics labeled as "not-valid", since these topics have been actively discussed by other members and were excluded just before the voting phase since some requirements at documentation level were missing (table 1). To analyze the data, we use a combination of quantitative methods, including social network and statistical analysis, and directed content analysis[3].

Format	Project	Nr. of discussion topics	Discussion topics, e.g.	Output
Challenge	Urban Mobility: Berlin 2030	81	Slot Powered Multifunctional Modular Platform	Concept for a mobility solution to be used in the urban context
Task-based	Olli: self-driving, cognitive electric shuttle	57	Olli Door Ingress/ Egress	Development of the self-driving shuttle Olli
Challenge	Autonomous for All of Us	76	Hearing Impaired Concept	Further development of Olli for all ability levels

Table 1: *Overview of projects and discussion topics related to the development of the self-driving shuttle Olli.*

[1] We asked Local Motors for permission to scrape and use data collected on http://localmotors.com. In a personal communication they kindly accepted that we use data generated by scraping the corporate website for scientific purposes.
[2] Due to privacy reason we anonymize username by assigning them a contributor ID.
[3] Anonymized data for nodes and edges are available at: https://docs.google.com/spreadsheets/d/1CvrXHBPhyDY9p3ooeU6os5LAnWMpiwRRA9qDVbFKUhI/edit?usp=sharing

4.2 Data modelling for network and statistical analysis

Since we took collaborators as basic unit of our analysis we defined each member as a node in our network. Following an approach diffuse in the OSS literature (i.e. Shen & Monge, 2011; Madey et al., 2002) we considered nodes to be tied by an edge if they contributed—previously or ensuing—to the same 'valid' discussion topic. A possible limitation to this approach could be related to time issues as suggested by Kavaler & Filkov (2016). They pose the question, if it is legitimate to link node A to node B, if node B contributed to a discussion topic where A previously took part, but A does not react furtherly. We still decided to adopt the bidirectional approach because (I) all discussion topics lasted for a relatively short time period; usually no longer than few weeks. Second (II), in the case of the two challenges, users voted by the end of the submission phase and were consequently supposed to review the proposals. Moreover, (III) some collaborators could have given feedbacks which have been integrated in the original proposal by the initiator of these discussions. These kinds of interactions are not tracked on the website, so that we could not exclude that they took place. For these reasons we decided to use the approach mentioned above.

As a consequence of this modelling strategy, nodes are undirected in our network, moreover each contribution—a solution proposal, an entry for a challenge or a simple feedback—are not distinguished qualitatively even if they represent different effort levels. Each edge has therefore a weight value of "1", but since two contributors can interact together on more than one discussion topic, edges are weighted differently. For example, if *a* and *b* contributed to discussion *x* and *y*, they will be linked by an edge with weight "2", if *a* and *c* contributed together only on discussion *x*, the edge between them will have value "1". After merging the data from different discussion topics, we enriched each node with the attributes shown in table 2 and each edge with the information shown in table 3. Moreover, in order to conduct our analysis, we built five networks: N1 represent the overall network made of all not-spammy interactions, N2 is a network made of interactions only between free collaborators and exclude therefore community managers, the network defined by the challenge "Urban Mobility: Berlin 2030" will be called SN-1, while the network derived out of the task-based project "Olli: self-driving, cognitive electric shuttle" will be named SN-2 and the third network related to the challenge "Autonomous for All of Us" will be labeled as SN-3.

Node's attributes	Value
Username	User_xyz
ID	Contributor-001
Is LM manager?	Yes or No
Nr. of Edges	Integer
Nr. of enjoyed discussion topics	Integer
Nr. of enjoyed discussion topics started from other contributors	Integer
Nr. of discussion topics started	Integer
Did the contributor took part to the project "Urban Mobility: Berlin 2030"?	Yes or No
Did the contributor took part to the project "Olli: self-driving, cognitive electric shuttle"?	Yes or No
Did the contributor took part to the project "Autonomous for All of Us"?	Yes or No
Is an awarded contributor?	Yes or No
Was the contributor awarded for the project "Urban Mobility: Berlin 2030"?	Yes or No

Was the contributor awarded for the project "Autonomous for All of Us"?	Yes or No
Has the contributor submitted a challenge proposal?	Yes or No
Has the contributor submitted a challenge proposal to the project "Urban Mobility: Berlin 2030"	Yes or No
Has the contributor submitted a challenge proposal to the project "Autonomous for All of Us"	Yes or No

Table 2: *List of all attributes collected for each node.*

Edge's attributes	Value
Source	Contributor ID
Target	Contributor ID
Edge type	undirected
Edge ID	Edge-001
Label 1	Project name, e.g. "Autonomous for all of us"
Label 2	Discussion topic name, e.g. "Berlino 3.0 - Smart mini bus system"
Is spam?	Yes or No
Is Not Valid?	Yes or No
Weight	Integer

Table 3: *List of all information collected for each edge.*

4.3 Directed content analysis

Since we want to analyze how the trade-off between open and closed participation, as well as between hierarchical and flat governance theorized by Pisano & Verganti works in practice, we conduct a directed content analysis (DCA). As suggested by Hsieh and Shannon

> "the goal of a directed approach to content analysis is to validate or extend conceptually a theoretical framework or theory. Existing theory or research can help focus the research question. It can provide predictions about the variables of interest or about the relationships among variables, thus helping to determine the initial coding scheme or relationships between codes." (Hsieh & Shannon, 2005).

Following this approach we classified the messages posted by the community managers in 5 categories—described in the table 4—and labeled them as hierarchical or flat form of governance, following the description given by Pisan & Verganti.

Category	Form of governance	Activity
Moderation of discussions	Hierarchical	Community manager tries to limitate discussion to issues which are relevant to and compatible with the current state of the project
Entry validation or rejection	Hierarchical	Community manager verifies and declares if requirement satisfy or not formal and technical requirements
Comment on an entry	Flat	Community manager offers his technical opinion about an issue as a normal contributor
Asking for clarification and promoting discussion	Flat	Community manager asks user to improve the quality of their contribution
Involving further users in the discussion	Flat	Community manager explicitly mentions some community members which are encouraged to give their opinion about a specific issue
Encouraging networking and cooperation	Flat	Community manager encourages contributors to collaborate on topic posted by other users

Table 4: *Code system for the content analysis.*

5. RESULTS

The current chapter is dedicated to explore the results of our data analysis. We will move from the three research questions defined above and apply statistical and network analysis. In the case of the third research question we will also use content analysis to investigate how community managers interact with free collaborators.

5.1 Research question 1

In the following, we aim to verify our hypothesis that interactions are positively related to successful proposals and that awarded contributors are involved in more interactions—started by them or not—than other not-awarded contributors. For this purpose two success marks are available in the network: the innovation awards assigned by Local Motors and the crowd-based voting system.

Regarding the first success mark, we segmented the contributors and proposals of SN-1 and SN-3 into two categories: "awarded" and "not-awarded"[4]. As can be seen from table 5 and 6, during both challenges the number of users, the number of interactions, and the average number of interactions per user are higher for awarded proposals than for not awarded ones.

[4] SN-1 and SN-3 were both conceived as a challenge and have therefore clear success marks: the final awards and the results of the community polls. SN-2 has not a clear success mark and it is therefore not taken into account here.

SN-1 // Urban Mobility: Berlin 2030		Awarded proposals	Not awarded proposals
Nr. of contributors per proposal	Avg.	8,73	3,72
	Median	8	4
	St. Dev.	2,97	1,57
Nr. of interactions per proposal	Avg.	18,73	6,17
	Median	14	5
	St. Dev.	10,23	4,53
Interactions per contributors	Avg.	2,05	1,56
	Median	1,9	1,3
	St. Dev.	0,55	0,78

Table 5: *Comparison of awarded and not-awarded proposals for SN-1.*

SN-3 // Autonomous for All of Us		Awarded proposals	Not awarded proposals
Nr. of contributors per proposal	Avg.	7,15	3,61
	Median	6	3
	St. Dev.	3,80	2,69
Nr. of interactions per proposal	Avg.	14,77	5,37
	Median	11	2
	St. Dev.	8,81	5,85
Interactions per contributors	Avg.	2,086	1,33
	Median	1,9	1
	St. Dev.	0,78	0,94

Table 6: *Comparison of awarded and not-awarded proposals for SN-3.*

The second success remark was the crowd-based voting system, where each contributor could judge the proposals on a scale from 1 to 5. We plotted the number of contributions per project as independent variable, the final vote a project got as dependent variable, and we found a moderate positive Pearson correlation (r=0,64, n=36) as shown by figure 2.

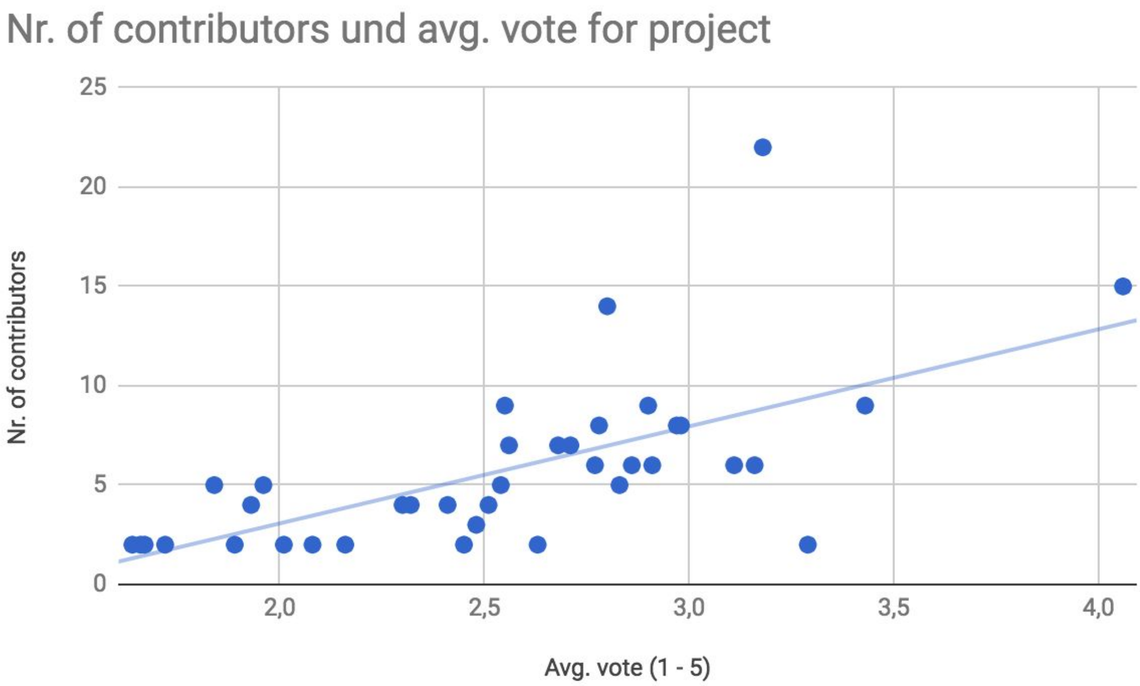

Figure 2: *Nr. of engaged contributors (y) and avg. vote (x) for each project. Note: Two strong outliners have been erased from the data sample for being suspected to be "spammy".*

A similar analysis at collaborators level also confirms the second part of our hypothesis. We found that interactions seem to have a positive effect on awards: Awarded contributors were more able to engage with other contributors as well as to generate more interactions, as suggested by table 7. Moreover, they were also more inclined to enjoy discussion topics started from other members.

Metrics		**Awarded contributors**	**Not awarded contributors**
Nr. of enjoyed discussion topics started from others	Avg.	3,58	1,45
	Median	2	0
	St. dev.	3,9	5,5
Nr. of engaged contributors for each started discussion topics	Avg.	10,68	3,68
	Median	8	3
	St. dev.	7	3,31
Nr. of generated interactions	Avg.	21,73	5,79
	Median	13	3
	St. dev.	18,56	7,8

Table 7: *Comparison of awarded and not awarded contributors for SN-1 and SN-3.*

The literature about OSSC demonstrates that products of collective effort, where many contributors interact together, can be of very high quality. The small data set available confirms that, also in the case of OSHC, success is positively related to the amount of interactions. Nonetheless, it is possible to explain this phenomenon in both directions: On the one hand, it can be interpreted that comments and reactions help contributors to clarify and further develop their proposals. But on the other hand, it can still be the case that members are able to recognize, and are more prone to discuss threads which are high-valuable and relevant. In that second case it would be the quality of proposals that drive interactions. Since there is not a log file of the submitted proposals, it is not possible to track their development from initial submission until the final stage, therefore we must conclude that there is a correlation between interactions and success, but no causal relation can be demonstrated.

5.2 Research question 2

In order to test our hypothesis, we built three networks, one for each project· and we compared their performance. SN-1 and SN-2 are composed by a similar number of members, each of the two graphs as about 90 nodes, while SN-3 is slightly bigger (122 nodes). That is probably due to a cumulative effect: contributors who already took part in the first two projects could have been motivated to return and enjoy the subsequent stages of the Olli's development (table 8).

Networks	Nodes	Edges	Unique edges	Avg. weight for node	Nr. of community managers	Nr. of collaborators	Nr. of discussion topics
N1	275	2.353	1.557	1,51	25	250	210
SN-1 // Challenge	91	714	417	1,71	3	88	80
Incidence on N1	33,09%	30,34%	26,78%		12,00%	35,20%	38,10%
SN-2 // Task-based	84	585	483	1,21	20	64	53
Incidence on N1	30,55%	24,86%	31,02%		80,00%	25,60%	25,24%
SN-3 // Challenge	122	1064	778	1,37	8	114	77
Incidence on N1	44,36%	45,22%	49,97%	90,50%	32,00%	45,60%	36,67%

Table 8: *Comparison of the networks N1, SN-1, SN-2 and SN-3 derived by the interactions on the projects.*

In order to investigate contributors' participation we considered two indicators: (I) the number of discussion topics joined by each contributor—which also include the discussion topics that a contributor started—and (II) the number of discussion topics joined by each contributor but started by other contributors. In both cases we excluded community managers and analyzed only free contributors. The two challenges SN-1 and SN-3 show a higher number of discussion topics joined by each contributor—for both indicators—in comparison to the task-based SN-2. During a challenge, each contributor joined approximately 2.4 projects, of which at least 1.6 were started from other contributors; the task-based project could motivate each contributor to interact on average with no more than 1,5 discussion topics. These data suggest therefore that challenges motivate contributors to join more discussion topics than task-based projects (table 9).

Metrics		SN-1: Berlin Mobility Challenge	SN-2: Olli: self-driving, cognitive electric shuttle	SN-3: Challenge: Autonomous for All of Us
Nr. of discussion topics joined by each free contributors	Avg.	2,41	1,5	2,45
	Median	1	1	1
	St. dev.	2,66	2,17	4,48
Nr. of discussion topics joined by each free contributors and started by other members	Avg.	1,6	1,26	1,75
	Median	1	1	1
	St. dev.	2,6	1,62	4,32

Table 9: *Comparison of contributors participation for SN-1, SN-2 and SN-3.*

This finding is also confirmed by another indicator: the number of contributors for each discussion topic. As shown by table 10 it is clear that during the challenges discussion topics were joined by more contributors (about 4) than SN-2, when averagely less than three contributors joined each discussion. Notwithstanding table 10 also suggests that the task-based topics were livelier discussed than the topics proposed during the challenge: Each contributor posted slightly more than 3 comments—as suggested by the contribution rate—for each discussion topic during the task-based project, while during the challenges a single contributor posted averagely less than two messages.

Metrics		SN-1: Berlin Mobility Challenge	SN-2: Olli: self-driving, cognitive electric shuttle	SN-3: Challenge: Autonomous for All of Us
Nr. of contributors for each discussion topic	Avg.	4,41	2,75	4,13
	Median	4	2	3
	St. dev.	2,5	2,56	3,15
Nr. of interactions for each discussion topic	Avg.	7,9	8,38	6,85
	Median	6	3	3
	St. dev.	7,06	13,28	7,13
Contribution rate	calculated as avg. interaction / avg. contributors)	1,79	3,05	1,66

Table 10: *Comparison of participation to discussion topics for SN-1, SN-2 and SN-3.*

Drawing upon these findings, we regard our hypothesis number two to be partially confirmed: contributors are more motivated to interact during challenges and—against our expectation—are not affected by a “competition mentality” since they are more prone to collaborate also on discussion topics and proposal started by other users. Nevertheless, contributors' behavior during the challenges looks to be much more superficial, in the sense that each contributor interacts with more discussion topics, but in a less intensive way compared to the task-based format. A possible explanation of these facts lies in the high modularity of the task-based project: from a contributor point of view, he or she will be only motivated to join discussion topics where he or she is interested in and ignores others which are not relevant to him or her. The task-based format attracts therefore less but much more interested contributors, who engage deeply in the discussion.

5.3 Research question 3

In order to verify our third hypothesis we proceed as follows: first, we do social network analysis in order to verify that community managers act as bridges in the innovation community—as stated by the literature about intermediaries; second, we make use of "directed content analysis" in order to evaluate the message posted by community managers in relation to our theoretical expectations.

We built our network N1 representing all interaction which took place during the innovation process. The resulting network is composed of 275 members and 1.557 edges. The average degree of the network is 11,3 and the median value is 6, which means that (1) there are some strong outliers as shown by the figure 3 representing a clearly right-skewed degree distribution and (2) that 50% of the members are connected to only a small portion—2,4%—of the network.

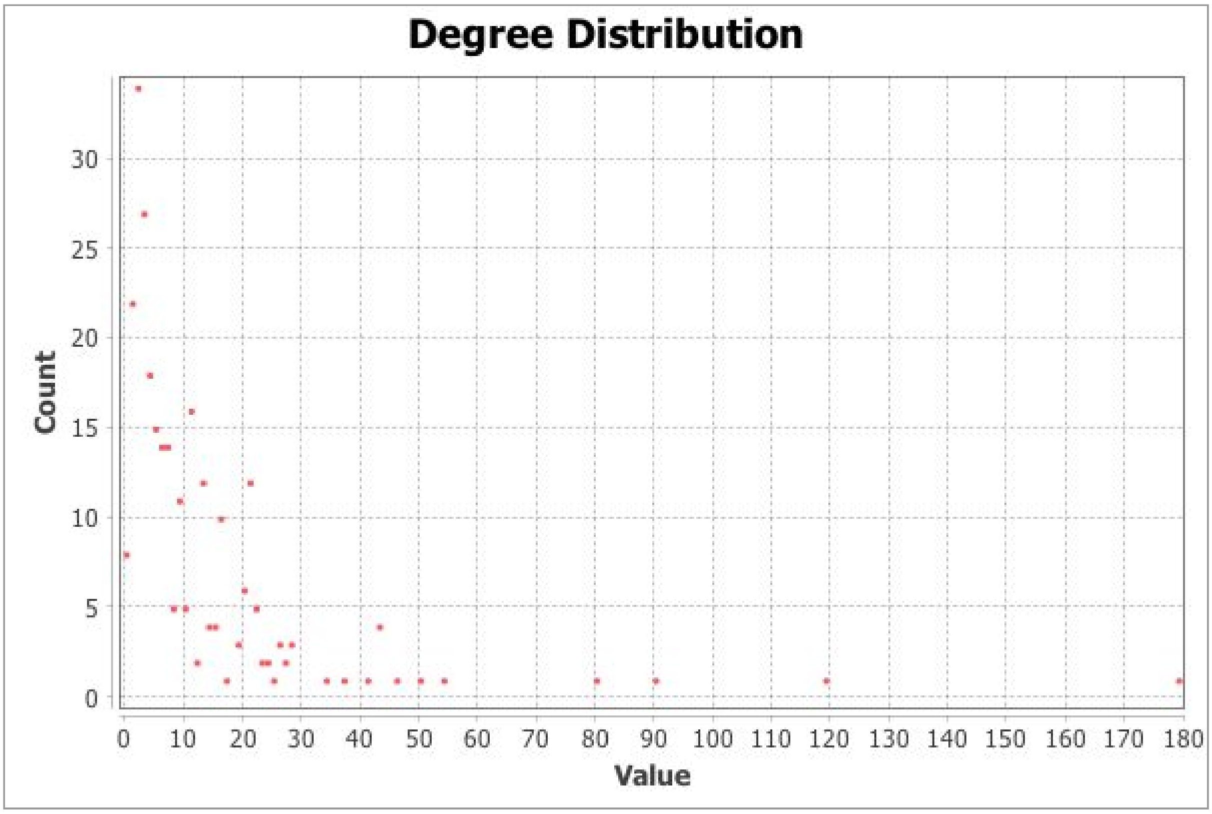

Figure 3: *Degree distribution of the whole network N1.*

We segmented the nodes between community managers and external collaborators and found out that community managers have an average degree of 26.4, while collaborators are connected averagely only to 9.8 further nodes. Community managers, who represent only 9% of the network's members (25 out of 275), are nonetheless involved in 47.8% of all edges in the network. Especially one member, plotted on the extreme low-right corner of figure 3, is a community manager with a degree score of 179, who connects to 71.6% of the network's nodes.

As shown in table 11 the analysis of other centrality degrees—closeness and betweenness—also show the fundamental role that community managers play in weaving the web of relationships in the community and in keeping the network alive. However—as attested by the high standard deviation values—not all community managers have above the average centrality degrees and act as intermediaries. Notwithstanding, even if some firm members interact only occasionally just in case of tasks where they have technical leadership, the first part of our hypothesis seems to be partially confirmed since there is at least one community manager which acts as a bridge between firm and collaborators as well as between the community members.

Metrics		**LM community managers**	**Free collaborators**
Degree	Mean	26.40	9.82
	Median	11	6
	Std. Dev.	39.79	11.50
Betweenness centrality	Mean	0.36	0.43
	Median	0.47	0.43
	Std. Dev.	0.24	0.05
Closeness centrality	Mean	1,273.8	59.12
	Median	37	0
	Std. Dev.	3,774.47	447.84

Table 11: *Comparison of centrality degrees for Local Motors community managers and free collaborators*

In order to verify the second part of our hypothesis and to better describe the intermediation function played by community managers we conduct a directed content analysis of the messages posted by the most active community manager—the one plotted at the right end of figure 2—who acts as a bridge between the different community members. Following our analysis (table 12) we found 55% of the messages to be inspired by flat governance techniques since they try to motivate users to improve their or third party entries, and 45% of messages to set the boundaries of the conversation as well as defining what is a valid contribution which should be further considered by other community members. The rather balanced mix between these two governance approaches seems to confirm the second part of our hypothesis and attests that firm-based OSHC need a balanced mix of flat and hierarchical forms of governance. Especially this second governance approach is needed to enclose the innovation process and to structure the *space in-between* in order to be prolific, while openness is clearly necessary in order to build and promote a fruitful environment of peer-to-peer collaboration.

Category	Form of governance	Observations	%
Moderation of discussions	Hierarchical	14	8,24%
Entry validation or rejection	Hierarchical	63	37,06%
	Total	**77**	**45,29%**
Comment on an entry	Flat	31	18,24%
Asking for clarification and promoting discussion	Flat	27	15,88%
Involving further users in the discussion	Flat	4	2,35%
Encouraging networking and cooperation	Flat	31	18,24%
	Total	**93**	**54,71%**

Table 12: *Result of the content analysis of all messages posted by the most active community manager.*

6. DISCUSSION

Our results have many implications from a theoretical, as well as from a managerial point of view. In the following, we highlight our contributions to the theory: While we confirm most of our expectations, we also identify some differences between empirical results and theory, which we attempt to explain.

6.1 Theoretical implications

Thanks to the development of Information and communications technology (ICT) and of collaboration tools (Baldwin & von Hippel, 2011, 1407), but also under the pressure of an era of radical innovation that has affected the whole industry (Ili et al. 2010), many firms in the automotive sector are experimenting with different co-creation strategies. Many of these strategies address the crowd, but only few of them aim to create a community of collaborators. Local Motors offers an interesting example of a long-term-oriented *innovation contest community* (Kathan et al., 2015) where the firm and community interact transparently for the joint development of a tangible good (Ehls, 2013, 13). We have been able to confirm that discussion and idea-sharing in a collective environment with like-minded people has a positive effect on the quality of a proposal, as shown by Baldwin et al. (2006) in the case of user-innovation and by Füller et al. (2006) in the context of open source communities. Our case demonstrates that the development of a community and of valuable ideas are mutually reinforcing, even in the case of firm-driven OSHC.

While, traditionally motivation has been analyzed through surveys, we used the engagement on the platform as a proxy of user motivation. We found two different forms of behavior related to the two different interaction formats. We assume that these two different ways to engage could be traced back to different motivational sources. Therefore, by adopting a different approach, we were able to confirm previous research, which found through surveys that reasons for participating in open-source projects are extremely various and complex. Developers who participated in open-source projects could not be regarded as all being motivated by a single driver (Hars & Ou, 2002). In contrast to other works on the motivation of open source participants in free communities (Lakhani & Wolf, 2005; Roberts et al., 2006) and firm-sponsored communities (Jeppesen & Frederiksen, 2006; West & O'mahony, 2008), we advance the hypothesis that participation in a community can result in different forms of engagement and behavior. Extrinsic motivation prompts collaborators to engage with peers, probably while animated by the desire to learn or the search for recognition. By contrast, task-based projects, which can only rely on intrinsic motivation, gave rise to, as theorized by Ryan & Deci (2000), a deeper commitment with the emotional object, the discussion thread.

Finally, we investigate the role of the actor designated to inhabit the innovation space between firms and collaborators. Our results show that community managers shape the *space in-between* by acting as a bridge connecting them with co-creators and prompting them to interact together. From the point of view of the theory of relation cohesion (Lawler et al. 2009, 44) repeated successful exchanges that are originally driven by self-interest, for example the desire to gain recognition, monetary reward or to learn, can introduce an expressive component which helps to foster long-term commitment to the community. Nonetheless, the creation of a firm-sponsored community raises questions about the governance of the innovation process (Dahlander & Magnusson, 2005, West & O'mahony, 2008). Our results show that community managers bargain with the community for the governance of the innovation process: they encourage co-creators to be creative, as well as to meet the requirements defined by the firm; they advance, but also accept proposals coming from the community. The case of Local Motors seems to suggest that the intermediation function played by community managers must be understood as a "dynamic capability" (Teece et al. 1997), which must be continuously adapted and re-configured in relation to an evolving and non-homogenous environment, where knowledge, motivations and goals are less formalized and not homogeneously shared by the collaborators. Compared to our initial framework proposed by Pisano & Verganti (2008), Local Motors seems to move back and forth between the two upper quadrant: sometimes the firm hierarchically manages an innovation contest and proposes some tasks, in other cases, it welcomes ideas, proposals and solutions started by the community (Figure 4).

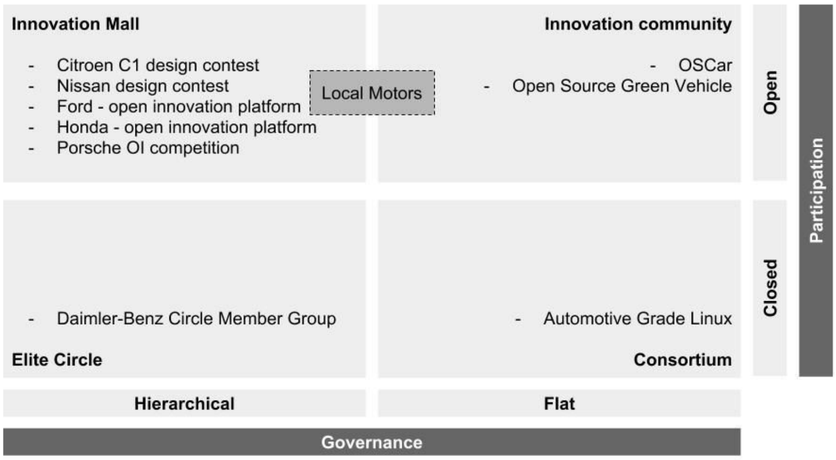

Figure 4: *Local Motors in relation to the taxonomy of open innovation model as proposed by Pisano & Verganti, 2008.*

6.2 Practical implications

Our analysis could help practitioners to handle three different questions. Firstly, we address the question of whether a firm should attempt to create a community for innovation purposes. Secondly, we investigated the question of the design of the innovation community. Thirdly, we attempt to describe how community managers actively contribute to the innovation process.

Regarding the first point, we found a correlation between the interactions between collaborators and the quality of the proposals; these seem to be mutually reinforcing. From a managerial point of view, it is therefore of extreme importance to figure out a strategy to get this mechanism started. Following the taxonomy of Pisano and Verganti, it seems reasonable either to invite proactively selected and valuable participants to join a closed community, in order to assure a high quality of contributions which can subsequently fuel discussions, or to work on community building by actively enhancing interactions between collaborators. In our case, Local Motors decided to follow this second—more troublesome—strategy.

Regarding the design of the innovation community, we could identify two different types of engagement. *Innovation contest communities* (Kathan et al., 2015) work well on widening interactions in a community, since collaborators are more interested in exploring and interacting with other collaborators and their proposals, in order to learn and gain visibility. Regardless, the modular task-based approach—inspired by the experience of OSSC (Colfer & Baldwin, 2016)—looks to be able to generate a higher commitment to discussion threads. From a managerial point of view it sounds reasonable to conceive of the design of an innovation community in relation to the kind of engagement that is needed. While a competitive environment could be useful for the very first phase of idea generation, a modular approach seems to be more able to recruit potential development partners, who are supposed to stick for a longer period of time and intensively with a given problem.

Moreover, we suggest that community managers should not just be simply conceived of as bridges between firms and communities, who pick up dispersed knowledge. They are invested with a much more relevant function since they actively shape the innovation space by engaging collaborators, fostering collaboration cultures and spreading ownership and commitment to the community.

6.3 Limitations & future works

The major limitation of our work is the small data set available. Further works could extend the analysis to bigger datasets which also consider further open innovation platforms in the automotive and other hardware industries, as for example in the case of Arduino, SparkFun Electronics, and Open Motors. Considering more players could help to give a more solid and comprehensive understanding of how firms manage OSHC and how the role of community managers must be understood from an innovation perspective.

A further limitation of our work relates to the methodology we chose. Further research could integrate semantic analyses in a larger scale to better examine the content that collaborators generate. These methods could be fruitful to analyze the micro-level of collaboration as well as the daily interactions and compare them to governance approaches, interaction formats and contribution quality.

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8. LIST OF FIGURES

(blue).
Figure 4: Local Motors in relation to the taxonomy of open innovation model as proposed by Pisano & Verganti, 2008.

9. LIST OF ABBREVIATIONS

ICT: Information and communications technology
OSSC: Open source software communities
OSHC: Open source hardware communities
OSH: Open source hardware
N1: Overall network
N2: Overall network without community managers
SN-1: Sub-network defined by the Challenge "Urban Mobility: Berlin 2030".
SN-2: Sub-network defined by the task-based project "Olli: self-driving, cognitive electric shuttle".
SN-3: Sub-network defined by the Challenge "Autonomous for All of Us"

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