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Requirements Engineering in Open Innovation and Software Ecosystems

Exploring the requirements engineering practices in the industry in the context of Open Innovation and Software Ecosystems

Master of Science Thesis in the Software Engineering Master Programme

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Abstract

Software companies are experiencing extensive pressure to be more innovative. A shift from closed organizations and processes towards open structures, where knowledge from external actors is joined to internal insights, proposes new forms of collaboration for innovative development. Thus, organizations are getting involved in new paradigms like Open Innovation. Furthermore, they open their platforms and form alliances participating and benefiting from the capabilities offered by a Software Ecosystem.

These new ways to innovate in a collaborative setting impact the requirement engineering processes creating the need to investigate how software companies perform requirement engineering when working with Open Innovation and shared platforms within a Software Ecosystem. Moreover, it is worth to research how innovative are the requirements that flow among the different actors in such a context. The purpose of this thesis is to study the industrial requirement engineering practices in the context of Open Innovation and explore how different actors interact and obtain different levels of innovative outcome.

This paper presents the results of a survey conducted in the form of an online questionnaire. Answers were collected from 50 practitioners involved in organizations in the contexts previously described. Particularly, elicitation, decision-making, and the innovation outcome were the topics studied. Furthermore, it was analyzes how industrial practices or outcomes are influenced by the role or the experience of the organization in the ecosystem.

Keywords: Requirement Engineering, MDRE, Open Innovation, Software Ecosystem.

Contents

1

Introduction

Innovation plays a significant role for organizations to remain competitive. Most firms consider that innovation is extremely important [1]. Furthermore, in most market domains, innovation is dependent on software components, even in industries that traditionally were not software-centric [1]. According to Wnuk et al. [2] this "increasing importance and density of software in today's products and services puts extensive pressure on excelling the discovery, description and execution of innovation". Consequently, software firms engage in new development approaches that can support faster innovation. What is more, a new paradigm, called Open Innovation (OI), has emerged for achieving the goal of more efficient innovation. Open Innovation considers knowledge to be widely distributed. Therefore, high-quality knowledge can come equally from internal or external sources. This exploitation of internal and external knowledge boosts innovation and expands the markets [2].

Furthermore, the software development effort is rarely constrained to a single company [3], investing in developers, technology, marketing, and sales [4]. Nowadays, forming alliances, participating and benefiting from the capabilities offered by a Software Ecosystem (SECO) is an emerging form of collaboration via the "sense of community" [4, 5]. This type of collaboration implies a shift from closed organizations and processes towards open structures where external actors become increasingly involved in the development [6]. In this context, software companies need to learn to open up their platforms and interact with other actors on the ecosystem level [7] while at the same time ensuring that the strategic goals are fulfilled [4].

As a result, these new emerging collaborative environments that promote innovativeness, challenge the current software engineering practices. In this vein, Wnuk and Runeson [2] propose a software engineering framework to foster Open Innovation. They identify requirements engineering processes for Open Innovation among the areas where further research is needed. Additionally, several authors point out the need of further research when it comes to deal with requirements among a number of actors in a Software Ecosystem [7, 8, 9, 10]. Consequently, this thesis aims to investigate the requirement engineering practices in industries that use Open Innovation engaged in a Software Ecosystem, particularly exploring

how actors interact and obtain different levels of innovative outcome. This study uses a survey in the form of an online questionnaire in order to find answers to these topics.

The remainder of this thesis is structured in this way: Section 2 presents the background and related work. Section 3 describes the methodology used in the study while results are covered in Section 4. Section 5 is dedicated to the discussion of the results, and finally Section 6 concludes the paper and presents future work.

2

Background and Related Work

This section starts with the background for the present work and provides definitions and main related concepts of these concomitant topics: Open Innovation, Software Ecosystems, and Requirement Engineering. Further, the related work subsection provides brief overviews of papers that address (from different perspectives) the aforementioned areas or others related, but do not focus on the purpose of the present paper. Even more, in most cases those papers constitute, as well, a base and point out the need (among others) of research on the requirement engineering process in OI and/or SECO/OSS. Thus, the motivation for the current study is also provided.

2.1 Background

2.1.1 Open Innovation

Even though innovation in open settings were not new practices [11], it was after Chesbrough 2003's publication [12] that Open Innovation became so attractive to scholars and practitioners [13]. It emerged as a new paradigm that significantly accelerates technical knowledge innovation in software firms by putting emphasis on co-innovation by internal and external actors to a company [2]. Chesbrough defines it as "the use of inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively". In addition, he discusses the associated mechanisms, including non-pecuniary and pecuniary flows.

Gassmann et al. [14] performed a study involving 124 companies and present a framework for Open Innovation identifying three core processes: The Outside-In archetype also known as inbound Open Innovation: "Integrating external Knowledge, Customers and Suppliers". The Inside-Out Archetype also known as outbound Open Innovation: "Bringing ideas to market, selling/licensing IP and multiplying technology". Finally, the Coupled type, which is a combination of the other two: "working in alliances with complementaries". Furthermore, they present the "Competence Perspective" in order to apply the Open Innovation approach effectively. Thus, in this perspective, for the Outside-in Process the Absorptive Capability is needed, in the same way, the Multiplicative Capability is related to Inside-out Process, and for the Coupled Process, Relational Capacity is required.

Gassmann's framework has been echoed in software engineering field. Particularly, Conboy et al. [15] make a refinement to the framework to guide research about Open Innovation in an agile development context, adding a new level of abstraction to the boundaries of the locus of innovation, this is, the firms units additionally to the firm itself.

Dahlander et al. [3] provide more details about openness regarding Open Innovation, and based on a systematic literature review, points out two inbound processes: sourcing and acquiring, likewise for outbound approach they indicate two processes: revealing and selling. In both cases the first process being non-pecuniary (sourcing, revealing) and the second pecuniary (acquiring and selling). For every process, Dahlander et al. [3] provide a definition and discuss the advantages and disadvantages.

It is also important to highlight that Open Innovation concept is analyzed in different domains [16]. Just for instance, Teece [17] includes Open Innovation as a part of business strategies, specifically as a part of dynamic capabilities. Besides all of the above, the core point behind Open Innovation is that companies cannot afford to be entirely dependent on their own internal innovations. Instead, they should systematically adopt and benefit from other companies' internal inventions through joint ventures, licensing, etc. and exploit all the potential, usually, within an ecosystem [7].

Regarding the type of innovation or classification of innovation, in general terms, not specifically to Open Innovation, Garcia et al. [18] provide a topology. Particularly they present a classification schema for product innovation combining two different levels: on one hand the market and technology level, and on the other hand micro and macro level. Where, the macro level is concerning if the product innovation is new to the world, the market or an industry while the micro level relates to being new to the customer or the firm. Making the possible combination, they suggest three "unambiguous labels": Incremental innovations, Really new, and Radical innovations.

2.1.2 Software Ecosystems

Software Ecosystems could be considered as a subset of digital ecosystems [19], which in turn are part of business Ecosystems. Even though Software Ecosystems are a quite new concept, business ecosystems have been around from the 90's [19]. Moore [20] takes natural (biological) ecosystems as a reference and points out that "For current businesses dealing with the challenges of innovation, there are clear parallels and profound implications". He suggests an inter-industry vision of companies evolving together to innovate, "they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations". Furthermore, developing new products in a business ecosystem has a positive influence on innovation as the process is faster than a single actor working alone [19, 20, 21]. Iansiti and Levien [22] identify 3 roles in a business ecosystem: keystones (also known as platform leaders) are those that mainly determine the growth of the ecosystem; niche players are those that leverage from the ecosystem to differentiate and succeed, they are smaller and tends to be many in the ecosystem; and value dominators, which take over the network and drain value from it [22]. Moreover, software, being different in a multitude of aspects [23], deserves its own category under business ecosystems [19]: Software Ecosystems.

There are different interpretations and consequently different definitions of Software Ecosystems [19, 24]. Messerschmitt et al. [23] provide the oldest definition [24] of Software

Ecosystems in 2005: “Traditionally, a Software Ecosystem refers to a collection of software products that have some given degree of symbiotic relationships”

Bosch [7] defines Software Ecosystems in this way “A Software Ecosystem consists of the set of software solutions that enable, support and automate the activities and transactions by the actors in the associated social or business ecosystem and the organizations that provide these solutions”. He also presents a taxonomy of Software Ecosystem in two dimensional space: Level of abstraction (namely, operating system, application and end-user programming) and evolution of the computing industry or platform dominance (namely, desktop, web, and mobile). Finally, he discusses transitioning to a Software Ecosystem and the implication in software engineering.

Jansen et al.’s [5] seem to be the most referenced definition in papers (followed by Bosch’s) [24]: ”A Software Ecosystem is a set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources and artifacts.” This definition of Software Ecosystem is the one that will used in this thesis.

Jansen et al.[19], also, highlight two important concept around Software Ecosystems: Software Ecosystems coordinators and software platforms. Software Ecosystems coordinators are those parties that govern or steer the ecosystem and profit when it thrives; they usually have control of the platform and are responsible for the future development of it. Software platforms are the instruments of value creation of the ecosystem. In order to have a healthy Ecosystem, the controlling part should not expropriate all the created value; instead they should share it and only receive a small part [22]. Regarding platforms, Gawer [25] argues that while platforms are (double/multiple)-sided markets from the economic point of view, from the engineering perspective they are modular architectures that promote generativity and innovation.

Additionally, Software Ecosystems consist of different type of actors: independent software vendors (ISV), outsourcers, and customers[5] and the relations among them and other actors could be complex and sometimes unclear[26]. In this vein, Yu and Deng[26] compare the buyer-supplier relationships in the traditional software supply chain to the open ecosystem format (from a mobile platform vendor's perspective). Furthermore, they present a model to show strategic dependencies between software vendor, third party developers, and end-users.

Moreover, Software Ecosystems (SECO) nurture co-innovations among different software producers with common interests [27]. SECO allows several actors to generate more value to the market than any of them can do on its own [19, 20, 21]. Thus, Software Ecosystems development approach is aligned with the basic assumption of Open Innovation with regards to collaboration with external actors.

2.1.3 Requirement Engineering

Many authors have presented definition of Requirement Engineering (RE)[28],[29],[30]. Sommerville [30] describes RE as the description of what the system should do; this implies services for the system, and constraints for its operation. Furthermore, the author points out that those services and constraints are found out, analyzed, documented and checked within the process of RE. Software requirements are classified as functional and non-functional

requirements. Functional requirements are “statements of services the system should provide” or in some case, what the system should not do. On the other hand, non-functional requirements are not directly related to the services that the system provides to the users. Instead, they are, usually, constraints on the services offered by the system as a whole, not specific services or functions.

Lauesen [31] identifies four different level in which requirements can be defined: Goal-level requirements are concerned about fulfilling business goals, Domain-level requirements describe user tasks that should be supported by the system. Product-level requirements are about functions that the software product should provide, and finally Design-level requirements present details of the software interface.

The requirement engineering process can be seen from two different points of views according to the type of market. When a software product is developed for a specific customer that assumes the cost of the development, it is a bespoke approach, better known as Customer-Specific RE. The result, in that case, is a product that fits the specific needs and demands of that single customer. On the other hand, the software product could be developed for a marketplace, with a vast number of potential customers and users. In this case, it is about a Market-Driven approach, better known as Market-Driven Requirement Engineering (MDRE).

Market-Driven Requirement Engineering (MDRE) differs from its customer-specific counterpart in those aspects in which the market plays a significant role. For example, time-to-the-market and gaining market share become paramount in such a setting.

Dahlstedt et al. [32] identify the major characteristics of MDSE: Time-to-market seems to be the primary goal that governs prioritization and release planning decisions; requirements are invented, because it is hard to collect them, mainly, due to the fact that, before the first release, only potential customers exists; Requirements are rarely written, in most cases because not a pressuring contract exists [33]. Furthermore, Dahlstedt et al. [32] describe the RE process as the following activities: Elicitation, Documentation, Analysis, Validation, Release Planning and Requirements Management. Particularly, in the Marken-Driven approach the decision-making activities play an important role, this is, prioritization and release planning.

There are other essential characteristics or particularities in MDRE, for example, regarding stakeholders, they depends on the targeted market segments, with the consequence of having no small set of customers and users. Competitors also play an important role and therefore confidentiality is an issue to consider. Additionally, in MDRE usually multiple releases need to be planned, and it is a challenge to deal with continuous inflows of new requirements, particularly since this frequently generates very large volumes of requirements [34].

2.2 Related Work

According to Edison et al. [6], innovation is the ability to dictate and modify the "rules of the game" that enables organizations to gain entry to new markets and challenge established market leaders. In today's competitive business environment, Organizations must continuously innovate and deliver novel products to achieve a competitive advantage. Furthermore and according to Wnuk and Runeson [2], the increasing density of software in today's products and services puts pressure on excelling the discovery, description and execution of innovation as the development of software products is mainly driven by innovation [2]. Thus, software companies are opening up their platforms and involving in Software Ecosystem in order to accelerate innovation. As these changes propose challenges to the requirement engineering process [2, 7], several authors discuss these topics and in many cases point out the need for further research in this regard.

In this vein, the study of Wnuk et. al. [35] discusses suggestions for adaptations of the requirement management process in order to exploit the potential of Open Innovation for companies involved in Open Source Software Development. This work is related to the purpose of the present paper, although their approach is mainly on managerial requirement engineering and specifically concentrated on Opens Source Software (OSS). Furthermore, this exploratory study does not aim to identify how companies perform RE in OI. They instead point out the need for future work in "understanding the impact of Open Innovation on requirements engineering processes ", which is addressed in the current study to some extent.

Similarly, another paper from Wnuk and Runeson [2], highlights that the software engineering literature lacks methods and tools for the full exploitation of technological advantages that Open Innovation can bring. Wnuk and Runeson identify research areas where both practitioners and researchers can benefit from further investigation. The areas include requirements engineering processes for Open Innovation, and software development processes that can support Open Innovation.

Likewise Open Innovation, Software Ecosystems also support the core concept of co-innovation. According to Wnuk et al. [36], the area of Software Ecosystems (SECO) is relatively a new field of research and Software Ecosystems is emerging as a means for several actors to jointly provide more value (innovation) to the market than any of them can do on its own. According to Joshua et al. [27] the innovative approach of developers, organizations, and third parties that have common interests is among the key features of SECO, and SECO fosters co-innovation among the software producers.

Since a Software Ecosystem has many stakeholders spread around and in many cases distant from the central ecosystem management, the elicitation of requirement seems to be quite challenging. In this regard, Fricker [8, 9] proposes a model for analyzing and designing flow of requirements through a Software Ecosystem based on negotiation and network theory [8]. What is more, he proposed the use of "requirement value chain" in order to propagate requirements [9].

Valença [10] presents a social oriented approach for Software Ecosystems evolution and proposes a ”Requirements Negotiation Model” to address the requirement negotiation process among the stakeholders. Furthermore, based on Software Platform Management he aims to define negotiation strategies along Software Ecosystem life cycle that maintain the ecosystem healthy and successful and provides reasoning on how requirement negotiation supports these goals.

Bosch [7], in turn, discusses the process of opening up platforms into Software Ecosystems and the implications for software engineering. He identifies “centralized requirements management and roadmapping” as one of the three implication within coordination mechanisms when transitioning to a Software Ecosystem (specifically, opening up a product line platform to a Software Ecosystem approach).

Knauss et al. [37] analyze challenges and opportunities for Requirement Engineering within a Software Ecosystem. Particularly, they studied the CLM ecosystem of IBM, through interviews with actors in the ecosystem, analysis of data from software repositories, and participatory observation. Furthermore, they identify trade-offs related to the openness in the ecosystem. One about acting with transparency, but still keeping confidentiality of intellectual property within the ecosystem. The other, regarding following a global strategy while being able to respond to the local needs of the users, ‘Just-in-time’ RE.

The motivations to do the study were formed by the aforementioned advantages of Open Innovation and Software Ecosystems. Moreover, considering the stated needs for further research in the intersect of the above mentioned areas with requirements engineering processes, in this study we will particularly focus on the requirements engineering processes of companies that use Open Innovation and are engaged in Software Ecosystems. We aim to discover how requirements engineering is conducted at those organizations and how innovative are the outcomes.

3

Methodology

This section presents the objective of the present study and the research approach. It starts with the purpose and research question, followed by the research design and data collection process and the data analysis. Finally, validity threats are discussed.

3.1 Research Purpose and Questions.

The specific purpose of this thesis is to study the industrial requirement engineering practices of elicitation, prioritization and release planning in the context of Open Innovation (OI) implementing Software Ecosystems (SECO); particularly exploring how the actors interact and obtain different levels of innovative outcome. Consequently with that purpose, the following research questions were formulated:

RQ1: How does requirement elicitation look like in Open Innovation?

Based on this first main question the following sub-questions were developed in order to address, particularly, the sources and frequency of requirements interchange and the measurement of innovativeness.

> RQ1.1: How often do practitioners receive requirements from other actors in Open Innovation?
> RQ1.2: How often do practitioners provide requirements to other actors in Open Innovation?
> RQ1.3: To what extent is innovativeness measured in organizations engaged in Open Innovation?

RQ2: How does Open Innovation affect prioritization and release planning?

RQ3: To what extent are received requirements from an Open Innovation context innovative?

RQ4: To what extent are provided requirements from an Open Innovation context innovative?

3.2 Research Design, Data Collection and Analysis.

In order to find answers to the research questions, a survey was conducted. An on-line questionnaire was used as the instrument for gathering data (see Appendix A). The questionnaire was made accessible on-line at www.soscisurvey.de.

The motivation for using this kind of instrument was to obtain a larger number of respondents than in the case of interviews though not with the same level of detail of this latter. Surveys are an appropriate strategy as a qualitative method for the characteristic of the present study.

The reason for selected a survey instead of other research methods like, for example, a case study, was the objectives to be achieved and, therefore, the type of research questions. A case study provides deep understanding of how and why particular phenomena occur [38]. Yin [39] presents the case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." Furthermore, this research method can be used to understand the mechanisms of causalities of relationships [38]. Nevertheless, since the case study focuses in detail in a particular real-life context, the result cannot be generalized. Moreover, the nature of the questions in the present study do not require such in-depth exploration, instead descriptive general understanding of the phenomenon.

A survey was considered the most suitable method to find answers to the research questions and fulfill the objective of this thesis. The research questions can be categorized as base-rate questions, mainly of frequency (e.g. RQ1.1, RQ1.2) and process type (e.g. RQ1, RQ2) [38]. These are well-defined research questions that examine the nature of a specific target population in a descriptive fashion. In addition, the survey method can be generalized i.e. identify what is true for practitioners in general in the target population. If instead the objective of the study would have been to get deeper insights from a particular real-life context, which no qualms about generalizability, then a better option would have been conducting a case study [39].

Now regarding the survey method, even though other possibilities exist, like structure interviews, online questionnaire was chosen for practical reasons, such as getting access to a larger number of respondents and the straightforward capability of gathering the data.

The population for the study was practitioners in software organizations working with Open Innovation. As it is usual when aiming to answer base-rate questions [38] a representative sample from the previously defined population was needed in order to use data analysis techniques to generalize from that sample to the population [38]

A convenience sampling (nonprobability) [40] approach was used. Most of the respondents participated as they could know about the study by references in our networks. Nevertheless, there were also participants from companies in technology parks in Sweden, companies working with Open Innovation. The first questions were designed to weed out participants that were not involved in Open Innovation or were not participating in a Software Ecosystem, as third party developers, in open source communities, or software vendors, etc.

The questionnaire was divided into three parts: part 1 regarding demographic information, part 2 addresses the requirement engineering process, and part 3 gathering data about the innovation outcome.

Part 1, demographics, had eight questions (Q1-Q8) most of them of single-choice type, but one question was of multiple-choice type (Q7), and one was a free-text input box (Q8). Part 2, Requirement Engineering process, had one general question, (Q9) which is more a demographic question related to the requirement engineering process, it was place at the beginning of this section as a natural, smooth movement to introduce the new part of the questionnaire. Following this first question, part 2 continues with two sub-sections: Elicitation and decision-making; the latter addressing prioritization and release planning. The Elicitation sub-section included five questions (Q10-Q14) being only the first one of the type multiple-choice while the rest were single-choice. Particularly, Q12 allowed categorization on a time scale; in most cases, a free-text was included for further details when applicable. The Decision Making sub-section had five questions as well (Q15-Q19) all of them were single-choice but Q15, which was free-text. Additionally, Q16 and Q19 allowed classification on a scale of frequency and level of difficulty. Finally, part 3 of the questionnaire, Innovation Outcome, contained six question (Q20-Q25) and included both single-choice and free-text questions.

Several questions in the survey had the "other" option available with the corresponding input box to specify the option not included in the list. In some questions the alternative to mark "I don't know" was also included. Information about the goals of the study was provided on the welcome page of the survey.

The questionnaire was sent to practitioners in software companies via e-mail, and the data was collected between 20th of April and 15th of May. The questionnaire was intended to be completed in 10 minutes, it was design with this in mind following the guidelines of Batinic et al. [41] regarding that, often, overlong surveys on the Internet are not completed.

Approximately 70 e-mail were sent to practitioners, of which 50 completed the survey; thus a response rate of 70% was received for this study. Additionally, 64 people started the survey, and 50 of them answered all the mandatory questions which gives completion rate of 78%.

For the data analysis, descriptive statistics and hypothesis tests were mainly used, different charts are presented as well as contingency tables with the corresponding Chi-Square tests were assumptions were fulfilled, but mostly Fisher's Exact test is used, since in most case the frequencies for each group were lesser than 5 or even zero (see Appendix B). For determining normality or not normality of data Kolmogorov-Smirnov Test was employed. As most data is not normal distributed, non-parametric tests were used for analysis. The most used test was the Chi-Square test. Furthermore, Correspondence Analysis (CoAn)[45] was also employed in several cases in order to describe the association in the data of the variables in contingency tables. Mann-Whitney U test was also used as looking for potential dependencies in the data. In all cases, the significance level was tested at the 0.05 (α=0.05) unless otherwise stated. The result of the analysis and the different tests performed can be found in Section 4.

3.3 Validity threats

This section presents the validity and threads of the research design and data collection considering the four perspectives of Wohlin et al. [42].

3.3.1 Construct validity

The construct validity is about who well the observations relate to the theories behind the research. The variables in the present study are measured through a survey where practitioners are requested to communicate their experiences in the industry; the survey instrument includes both closed and open-ended questions.

The potential problem of mono-operation bias was alleviated by collecting data different sources. Furthermore, free-text question were included to through the answers get any indication of misunderstanding. As anonymity was guaranteed to all the respondents, and this was emphasized at the beginning of the questionnaire, the evaluation apprehension problem was minimized. Hypothesis guessing (i.e. suggests trying to guess what is the aim of the study) could be a potential problem. Nevertheless, in order to mitigate this issue, the introduction at the beginning of the survey instrument contained the purpose of the study, an anonymity clause, and general information about the study. However, this threat of hypothesis guessing is not easy to eliminate completely.

Key concepts, such as software ecosystem or artifacts, were explicated defined in order to reduce the risk of misinterpretations by the respondents. A limitation of this study is the use of only one method to collect data since triangulation is important in empirical research. Nevertheless, free-text questions were included to get more in-depth information about similar closed questions and to some extent mitigate this limitation.

3.3.2 Internal validity

Internal validity is related to the risk of interferences that might affect the causal relationship between treatment and outcome. Furthermore, these interferences could be caused by alternative factors that could affect the factor under investigation; thus, it is important to be aware of any marginal cause. Threats to internal validity include instrumentation, maturation and selection threats.

To mitigate issues regarding instrumentation, the survey instrument for this study was reviewed by experienced researchers that have conducted similar studies. Additionally the instrument was designed taking to account the literature about Open Innovation and Software Ecosystem. Maturation in this context concerns to, for instance, learning effect or subject’s responses being influenced by boredom. As each respondent filled the questionnaire only once, the learning effect is minimized.

Additionally the survey was designed to take about 10 minutes to complete, thus, boredom could be mitigated as well. Furthermore, the fact that most respondents that started the questionnaire finished it (a completion rate of 78%), shows that participants were interested in the survey. Selection could be threatened due the fact that random sampling is not possible in this case, and it was opted a convenience sampling instead. Nevertheless, responses were gotten as well from practitioners outside our networks, reducing this issue.

3.3.3 External validity

The external validity refers to the ability to generalize the findings beyond the actual research, (i.e., the applicability of the results is beyond the participating organizations and could be generalized to other companies or individuals outside the study)

The influence and control of the researchers over the context where practitioners filled out the questionnaire was null since the actual setting of the study was an environment known to the subjects (from their own work of place using the web). The sampling is also an issue in external validity. In this study, no random sampling was feasible to performed; thus, convenience sampling was used. In a study like the present, it is very difficult to achieve random sampling, and even if it could be done to enforce external validity, other issues could threaten other aspects of the validity of the research. If contacts for the entire population were available and a random sampling were performed, it would be very hard to get volunteer answer for a majority of the requested practitioners. Additionally the obligation factor could negatively affect the results, weakening the validity due to threats of a non-voluntary nature. Even though the present study has not a huge number of respondents, the amount is large enough to be able to generalize the findings.

3.3.4 Conclusion validity

Conclusion validity reflects the ability to draw accurate or incorrect conclusions regarding relationships in the data. The issues of conclusion validity could be caused by several sources: instrumental flaws, influence posed on the subjects, or selection.

The instrumentation was revised by experienced researchers one of then conducting similar studies. This revision was done in order to reduce the threats related to instrumentation (i.e. misunderstanding of questions, definitions, formats, etc.) and to be able to use a high-quality questionnaire.

Concerning influence pose on the subjects, it is possible that eventually some subjects interact with each other, for example, those working in the same department in the same organization could share their answers or opinions and cause an influence on the outcome of the study. However, this problem is very difficult to alleviate. The sample selected for the investigation were practitioners; thus the group in general term were heterogeneous representing different roles and levels of experience, which should mitigate issues related to the selection.

4

Results

This section presents the outcomes of the study. It starts with a compilation of demographics about the participants of the survey. After that, and for a better understanding and follow-up, the remainder of this section is structure according to the research questions introduced at the beginning of the previous section, Methodology. Thus, In order to answer the research question one, implications of Open Innovation in elicitation of requirements, are presented. Next, the decision-making process is analyzed as an answer to research question two. Finally, the innovation outcome is presented for both received and provided ideas and artifacts, aiming to answer research question three.

4.1 Respondents Demographics

This section presents demographics about the respondents and the corresponding organizations they work in. This is with the purpose to know better the sample and as a sort of introduction for the different analyzes of the data that will be performed further in this chapter. Accordingly, exploring information such as the role of the organization in the ecosystem, the number of years working in the ecosystem, etc. becomes an important matter.

The number of respondents who started the survey was 68, with 50 that finished it completing all the mandatory questions. Figure 1 shows the distribution of respondents based on the position they have in their organizations. The most common role among them, with 10 people, was Project Manager (20%) follow very closely by the developers, 9 people (18%), and in the third place Requirement Engineers, 7 people (14%). These three roles constitute slightly more that 50% of the respondents. Regarding experience, 31 people, the majority (62%) of the participants in the survey, had between one and five years working in the organization. This is, from one to two year, 18 people (36%) and from three to five years, 13 people (26%). The most experience people in their organizations were 16% with more than 10 years, 8 people. See Figure 2, distribution of respondents based on the position they have in their organizations, for more details.

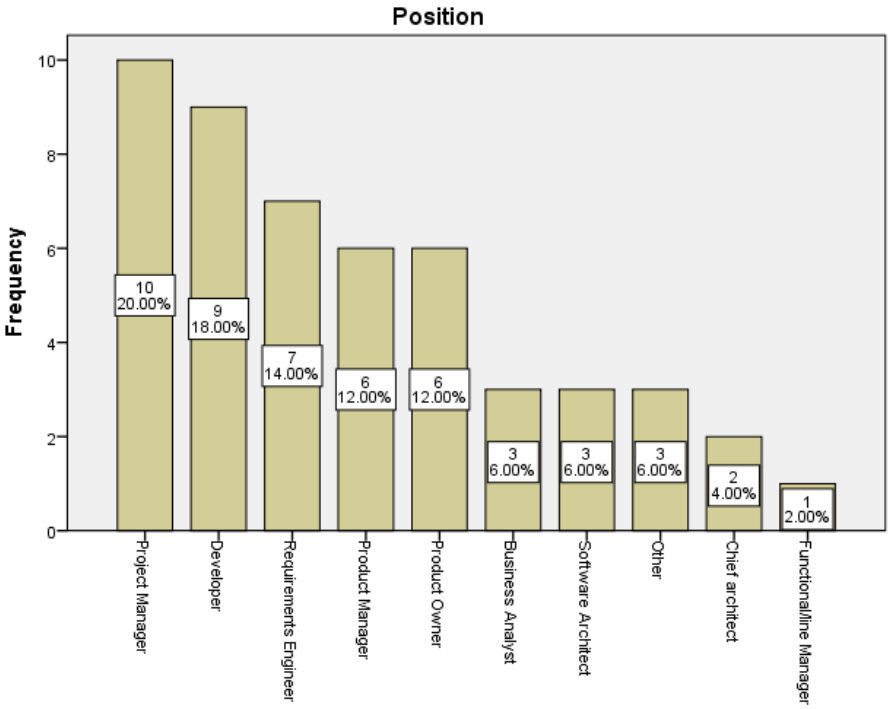

Figure 1. Distribution of respondents based on the position they have in their organizations.

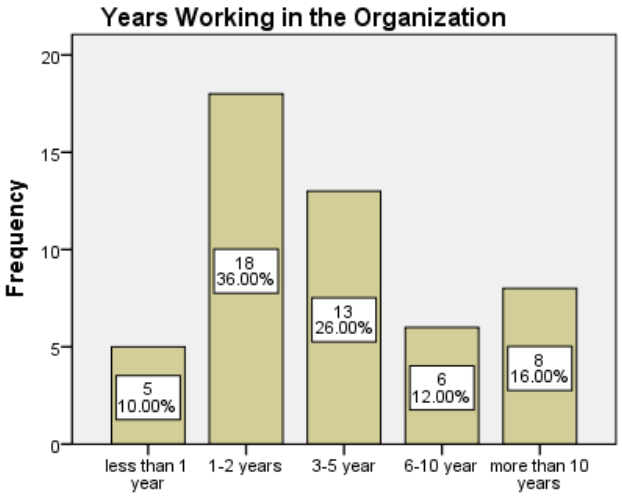

Figure 2. Distribution of respondents based on the position they have in their organizations.

Regarding the organizations the respondents work in, Figure 3 shows the distribution of respondents based on the category of the organization. Large companies and open source companies were the most common categories, each one of them selected by 13 people (24%). 11 people categorized the company they work in as a 3er party developer (approx. 20%). The same number of people selected Start-up as well (approx. 20%) while 6 people classified their companies as Joint ventures. Even though more than one category could be selected most of the respondents selected only one to describe their organizations. The exception were 4 cases with these simultaneous responses: 3rd Party developer and Large company; 3rd Party developer and Start-up; Start-up and Open source; and Start-up and Joint venture. Despite the fact that the corresponding question in the survey allowed to select the option "other", in case that someone could not find a category that represent the characteristic of the organization, no one selected this alternative (others 0%).

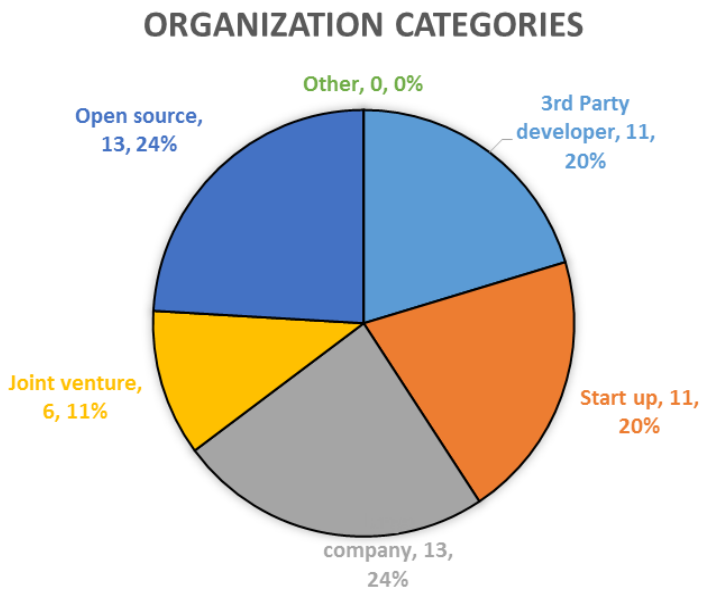

Figure 3. Distribution of respondents based on the category of the organization. Respondents could select multiple categories.

The respondents were quite uniformly distributed among the three different roles of their organizations. Even though there was not too much difference in the number of people in companies with every role, Platform owner was the most common one with 18 people(36%) in such an organization, follow by 16 people (32%) pertaining to a niche player organization. The third place was for platform co-owner just one person less than niche players and three less than platform owners, this is 15 people with a 30% of the cases were in a platform co-owner company. One person (2%) selected the "other" alternative, this was the case of a software vendor company.

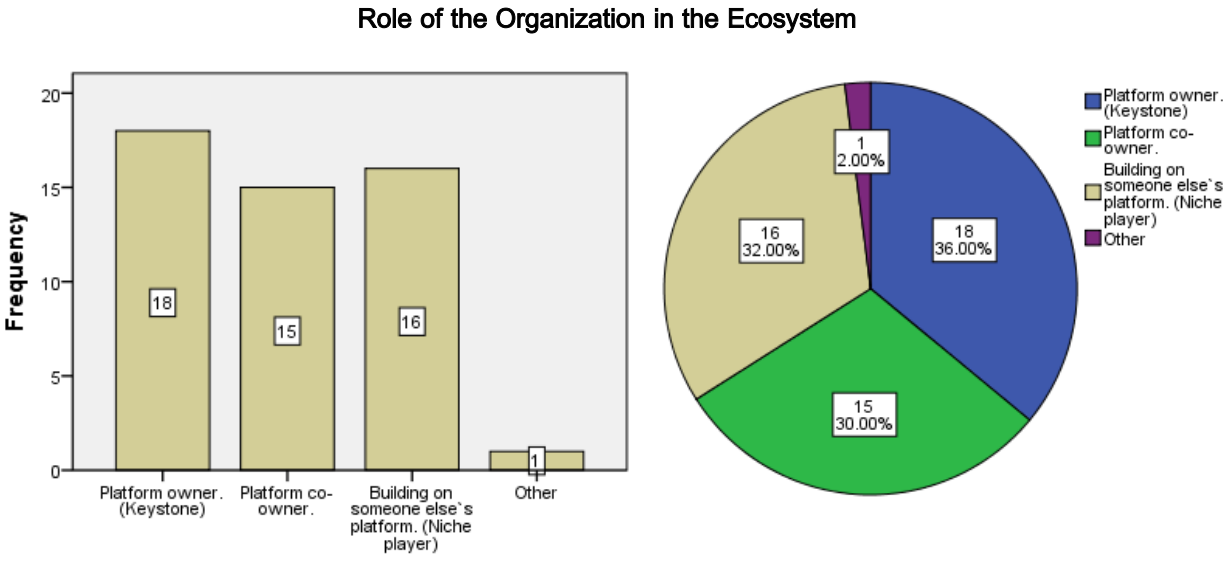

Figure 4. Distribution of respondents based on the role of the organization.

The distribution of respondents based on the numbers of years the organizations have been working within the ecosystem is shown in Figure 5. The smallest number of people were working in an organization with less than one year in its ecosystem, 8 respondents (16%). Those working in an organization with more than five years in its ecosystems were 12 (24%). 14 respondents pertained to organizations with four to five years in their ecosystems while the most common period of time was between two and three years with 16 people (32%).

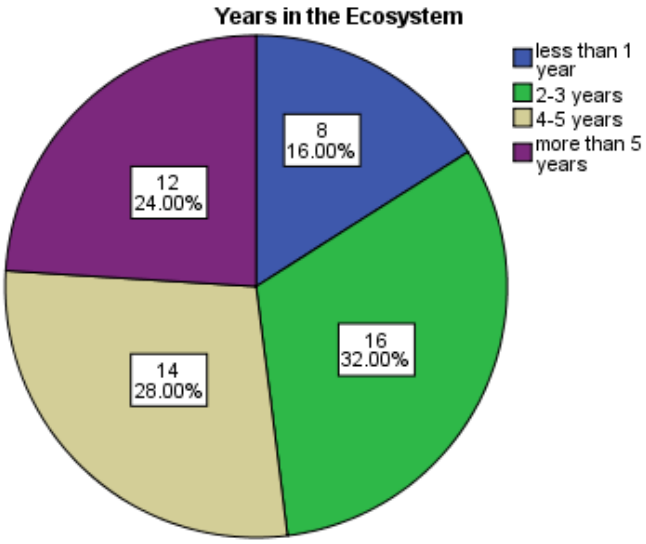

Figure 5. Distribution of respondents based on the numbers of years the organizations have been working within the ecosystem.

Additionally, the respondents are classified in the contexts they have worked with requirement in relation to an ecosystem. Those that have worked with requirements in both an ecosystem context and requirements handle only internally are the majority with 34 people (68%) identifying themselves in this case. The rest, 16 people (34%), responded that they have only worked with requirements in an ecosystem context. Figure 6 shows the complete distribution of respondents based on the fact of if they have worked in both ecosystem and no ecosystem context.

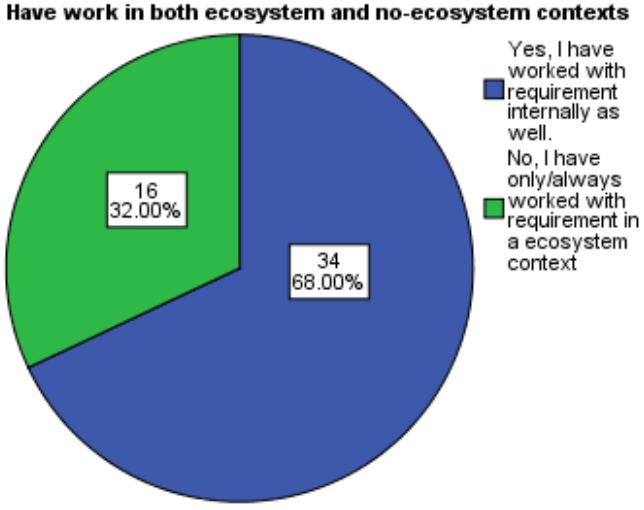

Figure 6. Distribution of respondents based on the fact of if they have worked in both ecosystem and no ecosystem context.

4.2 Open Innovation to elicit requirements (RQ1)

This section answers the first research question (RQ1) regarding how requirements elicitation looks like in Open Innovation and Software Ecosystems. The following aspects will be analyzed in this section in order to answer the research question: whom practitioners elicit requirements from, internal or external stakeholders, or both? Is it a narrow or a large set of stakeholders taken into account for elicitation? Do practitioners consider more easy/difficult to elicit requirement in an ecosystem? Does it depend on the role of the organization or the experience in the ecosystem?

The first matter addressed is from whom practitioners elicit requirements, either from internal stakeholder, external stakeholders or both of them simultaneously. Figure 7 shows that 41 respondents answered that they elicit requirement from external stakeholders while 30 respondents answered that they elicit requirement from internal stakeholders. One respondent declared not knowing the answer.

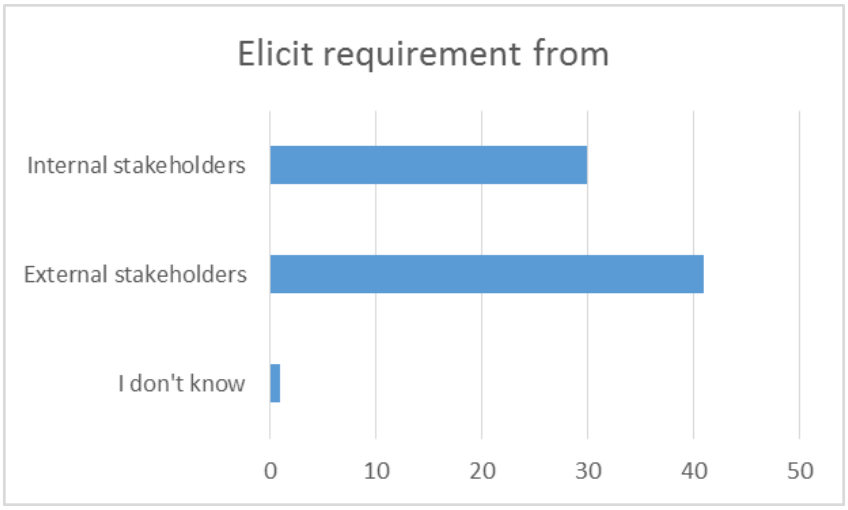

Figure 7. 41 respondents answered that they elicit requirement from external stakeholders while 30 respondents answered that they elicit requirement from internal stakeholders.

The respondents can select either only one option (external or internal stakeholder) or both simultaneously. This first graph (Figure 7) shows just the independent answers and does not visualize the concurrent selection of both internal and external stakeholders. However, it would be more interesting to see how many elicit requirement from internal and external stakeholders at the same time, which is presented down below.

Figure 8 shows explicitly how many selected that they elicit requirement from both internal and external stakeholders, which turn out to be the most common case with 22 practitioner (44 %) eliciting requirements in this fashion. Now let us consider those that selected that they elicit requirement from either internal or external stakeholders. Eliciting requirements from internal stakeholders only, represents the menority of the cases since 8 people (16%) declared to work in this way. As shown in the graph (Figure 8), there are, as well, those that only elicit requirement from external stakeholder, this group counted 19 practioners (38%).

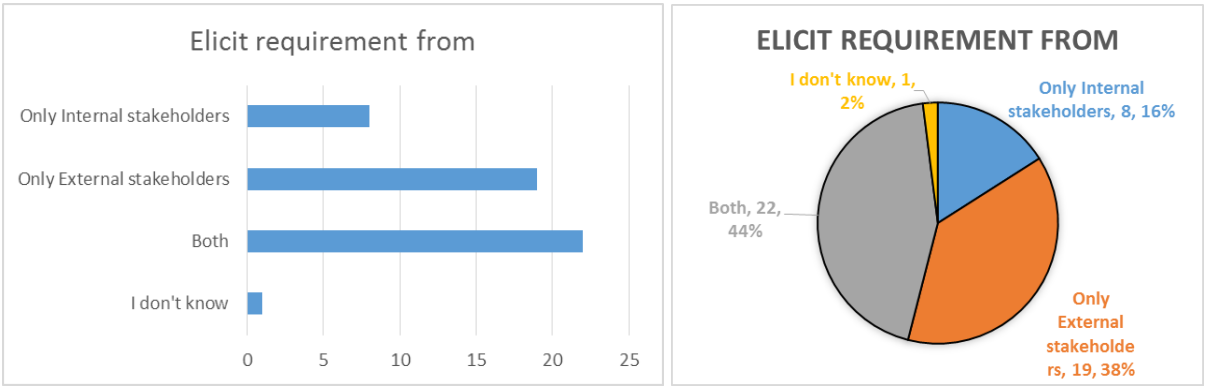

Figure 8. Compilation of answers making a distinction when both internal and external stakeholders are taking into account to elicit requirements.

Continuing to see how eliciting requirements in the given context looks like, the number of stakeholders from which requirements are elicited is analyzed. The pie chart below (Figure 9) allow us to visualize the distribution of the answers about the number of stakeholders to elicit requirement from: Large or narrow number of stakeholders. Those that elecit requirements from a large number of stakeholders, which is in fact, the majority, were 30 practitioners (60%), and those eliciting from a narrow set of stakeholders were 19 practitioners (38%). One respondent declared not knowing the answer (2%). In this cases, as is obvious, the answers were mutualy exclusive, and the respodents could select only one of them in the survery.

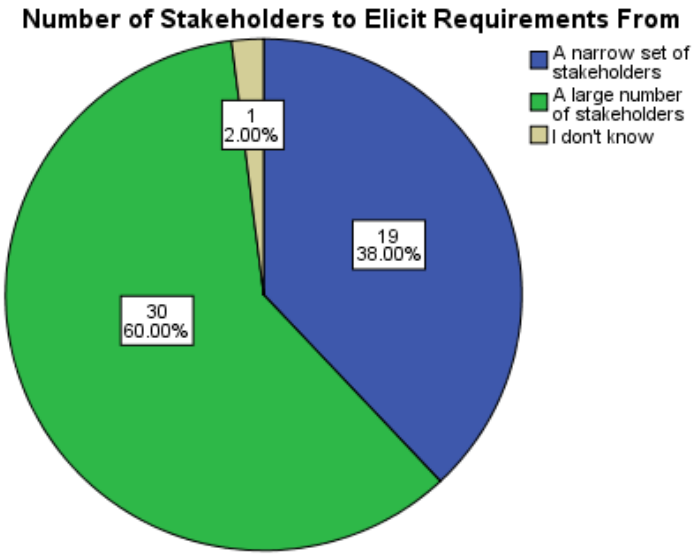

Figure 9. Distribution of the answers about the number of stakeholder practitioners elicit requirements from.

The last subject addressed in this first research question, and that is taken for further analysis, is the level of difficulty practitioners assign to eliciting requirements in an ecosystem context. First, descriptive statistics will be shown about how practitioners consider the level of difficulty of eliciting requirements in an ecosystem contexts contra a no ecosystem one. Then statistical analysis will be presented to evaluate if there is statistical significance for differences. After that, more analyzes will be presented to discover if the level of difficulty is dependable on the role of the organization or the degree of experience it has in the ecosystem.

Figure 10 provides an overview of the frequencies that practitioners categorized the difficulty of eliciting requirements in an ecosystem vs doing it in a no ecosystem context. The survey instrument was designed in such a way that only those that declared to have experience in both contexts (34 practitioners) could answer the question. For more details see Figure 6 in the last part of sub-section 4.1 Respondents demographics. Thus, 34 people answered the corresponding question in the questionnaire. From the graphic below (Figure 10) could be seen that 2 people (5.88%) thought that in an ecosystem it is easier to elicit requirements while, on the other hand, 15 people (44.12) considered more difficult to elicit requirements in an ecosystem. Furthermore, a Chi-Square test was run in the data set (variable *ReqSECOMoreDiff*) in order to statistically determined the significance of the differences, the results are shown in Table 1. Consequently with the descriptive statistics and the significance result of the analysis, it can be concluded that practitioners consider that eliciting requirements is more difficult in an ecosystem.

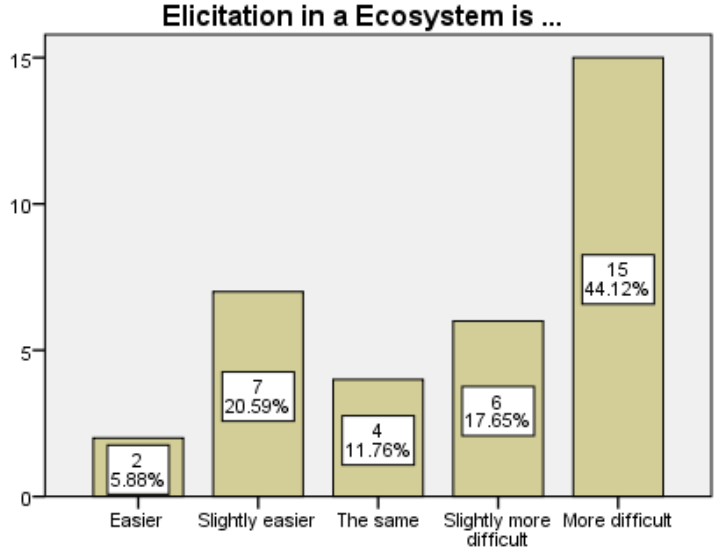

Figure 10. Level of difficulty of eliciting requirements in an ecosystem contra a no ecosystem context.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of ReqSECOMoreDiff: Elicitation occur with equal probabilities.	One-Sample Chi-Square Test	.006	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 1. Result of Chi-Square test to determine the probabilities of equal frequencies in the levels of difficulties of the variable ReqSECOMoreDiff.

Once it was found that it is more difficult to elicit requirements in an ecosystem, there are more interesting aspects to consider: Is this difference in eliciting requiremnets dependable on the role or the experience of the organization in the ecosystem? Table 2 is a contingency table for the first aspect mentioned: the rows list the roles in the ecosystem while the columns present the level of difficulty. Let us focus in the last column, "More Difficult". The greater value 8, correspond to 8 practitioners working in a platform-owner organization that considered elicitation in an ecosystem as more difficult. Continuing down in the same column, 4 practitioners in a platform-co-owner organization and 3 in a niche player thought in the same way.

RoleInSECO * ReqSECOMoreDiff: Elicitation Crosstabulation

Count

		ReqSECOMoreDiff: Elicitation					Total
		Easier	Slightly easier	The same	Slightly more difficult	More difficult	
RoleInSECO	Platform owner. (Keystone)	1	1	3	1	8	14
	Platform co-owner.	0	2	0	2	4	8
	Building on someone else`s platform. (Niche player)	1	4	1	3	3	12
Total		2	7	4	6	15	34

Table 2. Contingency table showing the interrelation of the role of the organization in the ecosystem and the level of difficult in eliciting requirement in that context.

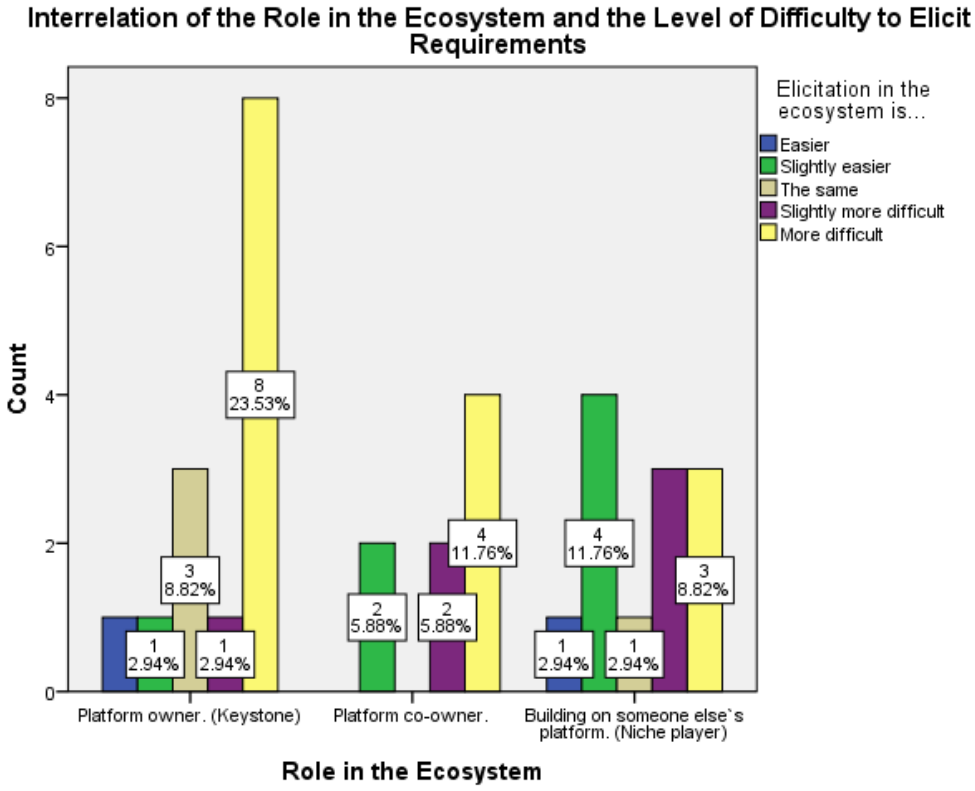

Figure 11. Bar chart providing a visual overview of the interrelation of the role of the organization in the ecosystem and the level of difficult in eliciting requirement in that context.

This information, and even more the corresponding bar chart (Figure 11) with a notable long bar with the value 8, might make us think that there are differences depending on the role. Nevertheless, this value 8, albeit the greatest, represents just slightly more than the half of 14 practitioners (see column "Total") involved in a platform owner, which is, in relative terms, not that impressive. In consequence, a statistical test should be used to determine with more certainty if there are significant differences depending on the role of the organization. Table 3 presents the results of the data analysis. As the assumptions of the Chi-Square test are not fulfilled (see Appendix B) the p-value of the Fisher's Exact test (third row in Table 3) is considered in this case to determine if there is statistical significance regarding differences in the role of the organization. The results show that since the p-value is greater than 0.05 (.402>.05), the differences are due to chance variation.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	8.139[a]	8	.420	.457		
Likelihood Ratio	9.914	8	.271	.455		
Fisher's Exact Test	8.092			.402		
Linear-by-Linear Association	1.849[b]	1	.174	.178	.100	.023
N of Valid Cases	34					

a. 13 cells (86.7%) have expected count less than 5. The minimum expected count is .47.

b. The standardized statistic is -1.360.

Table 3. Result of Chi-Square test to determine the statistical significance regarding differences in the role of the organization in relation to the level of difficulty to elicit requirement in an ecosystem context.

Now that it has been concluded that the level of difficulty in eliciting requirements is not dependent on the role of the organization, let us analyze the second aspect. Is this difference in the level of difficulty dependable on the number of years the organization has been involved in the ecosystem (the experience in the ecosystem)?

YearsCompInSECO * ReqSECOMoreDiff: Elicitation Crosstabulation

Count

		ReqSECOMoreDiff: Elicitation					
		Easier	Slightly easier	The same	Slightly more difficult	More difficult	Total
YearsCompInSECO	less than 1 year	0	2	0	1	3	6
	2-3 years	1	0	1	2	5	9
	4-5 years	1	2	1	1	4	9
	more than 5 years	0	3	2	2	3	10
Total		2	7	4	6	15	34

Table 4. Contingency table showing the interrelation of the experience of the organization in the ecosystem and the level of difficulty in eliciting requirement in that context.

An analysis similar to the first aspect was performed in this case as well. The descriptive statistics are shown in Table 4, a contingency table for the interrelation of experience of the organization in the ecosystem and the level of difficulty to elicit requirements; additionally, the corresponding frequencies plot is presented in Figure 12. Furthermore, the statistical test to determine significance is presented in Table 5, similar to the previous case, the assumptions of the Chi-Square test are not fulfilled (see Appendix B) the p-value of the

Fisher's Exact test (third row in Table 5) is then considered. In this case, the results show that since the p-value is one more time greater than 0.05 (.892>.05), the differences are due to chance variation.

Consequently with the statistical analysis afore presented it can be concluded that, in general, even though practitioners consider that eliciting requirements is more difficult in an ecosystem, after looking into differences between the role of the organization in the ecosystem and its experience in it, it cannot be concluded that such different depends neither on the role nor on the level of experience.

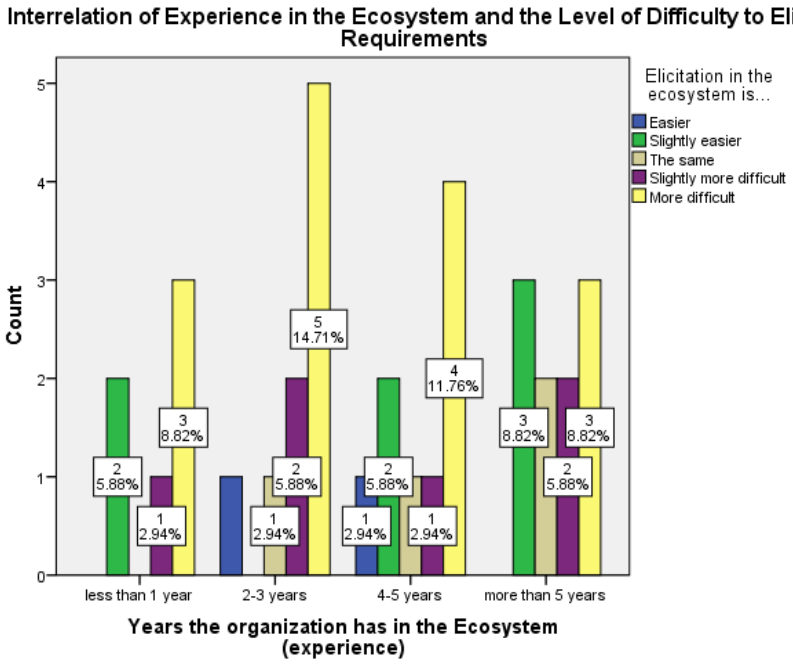

Figure 12. Bar chart providing a visual overview of the interrelation of the experience of the organization in the ecosystem and the level of difficulty in eliciting requirement in that context.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	6.960[a]	12	.860	.915		
Likelihood Ratio	10.114	12	.606	.855		
Fisher's Exact Test	7.866			.892		
Linear-by-Linear Association	.638[b]	1	.424	.459	.233	.034
N of Valid Cases	34					

a. 20 cells (100.0%) have expected count less than 5. The minimum expected count is .35.

b. The standardized statistic is -.799.

Table 5. Result of Chi-Square test to determine the statistical significance regarding differences in the experience of the organization in relation to the level of difficulty to elicit requirement in an ecosystem context

4.3 How often receives requirements from other actors (RQ1.1)

This section addresses the first research sub-question (RQ1.1) about how often practitioners receive requirements from other actors in the ecosystem in an Open Innovation setting. First, descriptive statistics are presented showing the distribution of the frequencies categorized on a scale from never to all the time. After that, two potential influencing factors are investigated in order to discover any dependency: Is the frequency at which practitioner receive requirements dependent upon the role of the organization or its experience in the ecosystem?

Figure 13 illustrates how often practitioners receive requirements from other actors in the ecosystem. It shows that 10 people (approx. 20%) never receive requirements from other actors; 20 people (approx. 42%) receive requirements seldom; 10 people (approx. 20%) receive them usually while 8 respondent (approx. 17%) affirm they receive requirements all the time. Two respondents declare not knowing the answer, and that is why the total number of people in the graph is 48.

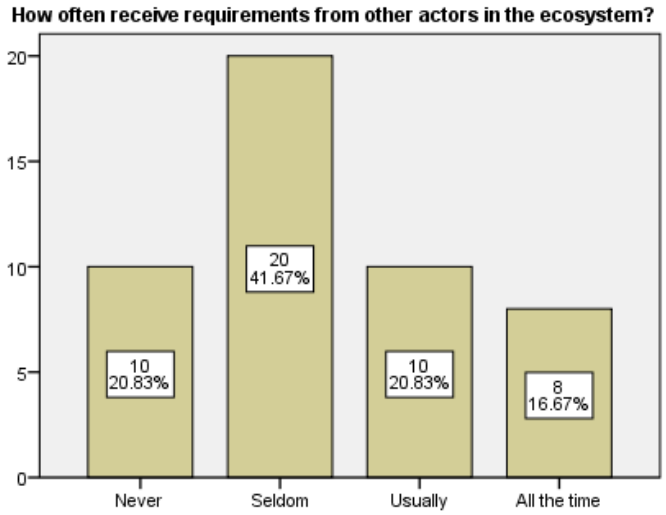

Figure 13. Distribution of the frequency that practitioners receive requirements from other actors in the ecosystem.

Furthermore, a Chi-Square test was used to determine if there is statistical significance beyond what descriptive data shows, the results are presented in Table 6. The p-value (p=0.062) reveals that there is not significance at an alpha level of 0.05 (α=0.05, p>α, 0.062>0.05).

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of RequirementsFromTo: receive requirements from other actors in the ecosystem? occur with equal probabilities.	One-Sample Chi-Square Test	.062	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 6. Result of a Chi-Square test to determine equal probabilities of occurrence for the different frequencies practitioners receive requirements from other actors.

Further investigation was done in order to discover if there is a connection between the frequency of receiving requirements in Open Innovation and the role or experience of the organization in the ecosystem. Table 7 is shows the correlations of the first aspect already mentioned, the role of the organization, with the frequency of receiving requirements. In general, the data in this contingency table suggests no dependency between the factors. The most remarkable value would be only one person working in a platform co-owner stating that receives requirements all the time, in comparison with 3 and 4 people pertaining to a platform owner and a niche player respectively. To confirm what the descriptive analysis seems to indicate, a Fisher's Exact test was run (see Table 8). In this case the assumptions for a Chi-Square were not fulfilled (see Appendix B). The significance (p=0.855) demonstrate that there is no correlation between the frequency of receiving requirements in Open Innovation and the role of the organization in the ecosystem.

RoleInSECO * RequirementsFromTo: receive requirements from other actors in the ecosystem? Crosstabulation

Count

		RequirementsFromTo: receive requirements from other actors in the ecosystem?				
		Never	Seldom	Usually	All the time	Total
RoleInSECO	Platform owner. (Keystone)	3	7	4	3	17
	Platform co-owner.	4	6	4	1	15
	Building on someone else`s platform. (Niche player)	3	7	2	4	16
Total		10	20	10	8	48

Table 7. Contingency table showing the interrelation of the role of the organization in the ecosystem and the frequency practitioners receive requirement from other actors.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	2.803[a]	6	.833	.850		
Likelihood Ratio	3.034	6	.805	.839		
Fisher's Exact Test	2.971			.855		
Linear-by-Linear Association	.003[b]	1	.954	1.000	.511	.069
N of Valid Cases	48					

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is 2.50.

b. The standardized statistic is .058.

Table 8. Result of Chi-Square test to determine the statistical significance regarding differences in the role of the organization in relation to the frequency practitioners receive requirement from other actors.

Let us know consider the second aspect, the experience in the ecosystems. A similar analysis was performed in this case. The descriptive statistics are shown in Table 9, with the correlation of values for the experience in the ecosystem and the frequency practitioners receive requirements in Open Innovation. Here, similar to the case of the role in the ecosystem, the experience does not appear to influence how often practitioners receive requirements from other actors. This result was confirmed with a Fisher Exact test (p=0.117, see Row 3 in Table 10).

YearsCompInSECO * RequirementsFromTo: receive requirements from other actors in the ecosystem? Crosstabulation

Count

		RequirementsFromTo: receive requirements from other actors in the ecosystem?				
		Never	Seldom	Usually	All the time	Total
YearsCompInSECO	less than 1 year	2	5	1	0	8
	2-3 years	6	6	4	0	16
	4-5 years	1	5	2	5	13
	more than 5 years	1	4	3	3	11
Total		10	20	10	8	48

Table 9. Contingency table showing the interrelation of the experience of the organization in the ecosystem and the frequency practitioners receive requirement from other actors.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	14.264[a]	9	.113	.111		
Likelihood Ratio	17.190	9	.046	.097		
Fisher's Exact Test	13.123			.117		
Linear-by-Linear Association	7.299[b]	1	.007	.007	.004	.001
N of Valid Cases	48					

a. 14 cells (87.5%) have expected count less than 5. The minimum expected count is 1.33.

b. The standardized statistic is 2.702.

Table 10. Result of Chi-Square test to determine the statistical significance regarding differences in the experience of the organization in relation to the frequency practitioners receive requirement from other actors.

In summary, these results show that even though it might be a significance (with α=0.10) in the frequency practitioners receive requirements from other actors in Open Innovation, this would not be related to neither the role nor the level of experience the organization has in the ecosystem.

4.4 How often provides requirements to other actors (RQ1.2)

This section continues to analyze the elicitation process in Open Innovation and Software Ecosystems. Now let us perform a similar analysis of the previous section, but in this time the focus will be in the frequency practitioners provide requirements to other actors in the ecosystem in an Open Innovation setting, which was the subject of the second research sub-question (RQ1.2). Like in answering the previous question, here the results are presented initially with an overall descriptive statistics followed by the analysis of the two potential influencing factors afore-mentioned to discover any underlying correlation: Is the frequency at which practitioner provide requirements dependent upon the role of the organization or its experience in the ecosystem?

To begin with, descriptive statistics about how often practitioners provide requirements to other actors in the ecosystem are shown in Figure 14. It can be seen that 15 practitioners (approx. 31%) seldom provide requirements to other actors in the ecosystem; the same number of people (15, approx. 31%) provide requirements usually; while 11 practitioners (approx. 22%) never provide requirement and, finally, 8 people (approx. 16%) provide them

all the time. The total number of people in the graphic is 49 since one respondent declared not knowing the answer.

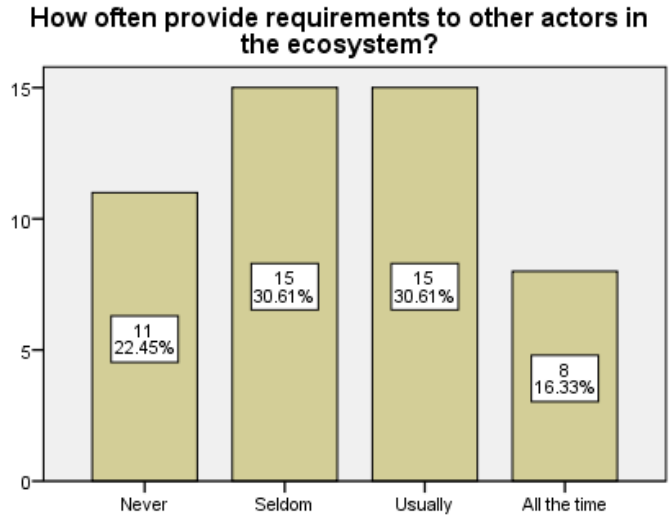

Figure 14. Distribution of the frequency that practitioners provide requirements from other actors in the ecosystem.

As in the previous section, a Chi-Square test was used to identify if statistical significance exists to prove equal probabilities of occurrence for the different frequencies that practitioners provide requirements to other actors. The results, as shown in Table 11, indicate that the null hypothesis cannot be rejected (p=0.417).

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of RequirementsFromTo: provide requirements to other actors in the ecosystem? occur with equal probabilities.	One-Sample Chi-Square Test	.417	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 11. Result of a Chi-Square test to determine equal probabilities of occurrence for the different frequencies practitioners provide requirements to other actors.

Likewise, it was interesting to dig further and see if the role of the organization or its experience in the ecosystem affect the frequency practitioners provide requirements to others. With this purpose, contingency tables were analyzed for both cases: interrelation of the role of the organization in the ecosystem and the frequency practitioners provide requirement to other actors (Table 12); and the interrelation of the experience of the organization in the ecosystem and the frequency practitioners provide requirement to other actors (Table 14). For both cases, Fisher's Exact tests were used to see if any correlation exists. The Fisher's Exact test did not show any significant differences between either the role (Table 13) or the experience (Table 15) of the organization with the frequency practitioners provide requirements to other actors in the ecosystem.

RoleInSECO * RequirementsFromTo: provide requirements to other actors in the ecosystem? Crosstabulation

Count

		RequirementsFromTo: provide requirements to other actors in the ecosystem?				
		Never	Seldom	Usually	All the time	Total
RoleInSECO	Platform owner. (Keystone)	2	7	7	2	18
	Platform co-owner.	5	5	3	2	15
	Building on someone else`s platform. (Niche player)	4	3	5	4	16
Total		11	15	15	8	49

Table 12. Contingency table showing the interrelation of the role of the organization in the ecosystem and the frequency practitioners provide requirement to other actors.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.119[a]	6	.529	.556		
Likelihood Ratio	5.323	6	.503	.552		
Fisher's Exact Test	5.134			.549		
Linear-by-Linear Association	.019[b]	1	.891	.934	.479	.066
N of Valid Cases	49					

a. 10 cells (83.3%) have expected count less than 5. The minimum expected count is 2.45.

b. The standardized statistic is .138.

Table 13. Result of Chi-Square test to determine the statistical significance regarding differences in the role of the organization in relation to the frequency practitioners provide requirement to other actors.

YearsCompInSECO * RequirementsFromTo: provide requirements to other actors in the ecosystem? Crosstabulation

Count

		RequirementsFromTo: provide requirements to other actors in the ecosystem?				
		Never	Seldom	Usually	All the time	Total
YearsCompInSECO	less than 1 year	3	1	2	2	8
	2-3 years	3	7	4	2	16
	4-5 years	3	5	5	1	14
	more than 5 years	2	2	4	3	11
Total		11	15	15	8	49

Table 14. Contingency table showing the interrelation of the experience of the organization in the ecosystem and the frequency practitioners provide requirement to other actors.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.962[a]	9	.744	.775		
Likelihood Ratio	6.091	9	.731	.801		
Fisher's Exact Test	6.048			.775		
Linear-by-Linear Association	.598[b]	1	.439	.450	.243	.041
N of Valid Cases	49					

Table 15. Result of Chi-Square test to determine the statistical significance regarding differences in the experience of the organization in relation to the frequency practitioners provide requirement to other actors.

Finally in this section, an additional consideration was analyzed: Do practitioners receive requirement from other actors more often than the frequency they provide requirement to others? Or vice-versa? Or is there not a difference between how often they receive and provide requirements?

Receive	Provide
Usually	Seldom
All the time	Usually
I don`t know	I don`t know
Never	Never
...	...

Regrouped

Frequency	Direction
Usually	Receive
All the time	Receive
I don`t know	Receive
Never	Receive
...	Receive
Seldom	Provide
Usually	Provide
I don`t know	Provide
Never	Provide
...	Provide

Figure 15. Exemple of regrouping frequency that practitioners receive and provide requirement.

In order to answer this, a new dataset was created with the data regrouped and adding a new column with the Direction, that is, received or provided requirements. Figure 15 shows graphically an example of the this regrouping and the resulting dataset. In this way, it was possible to determine the mean and mean rank of the Frequency for each group. Aditionally, Figure 16 present the corresponding bar chart comparing the frequencies practitioners receive vs. the frequency they provide requirements. Table 16 shows a descriptive statistics summary for the Frequency and Direction. Since in Frequency there were a total of 3 "I don't know" answer, the N value is 97.

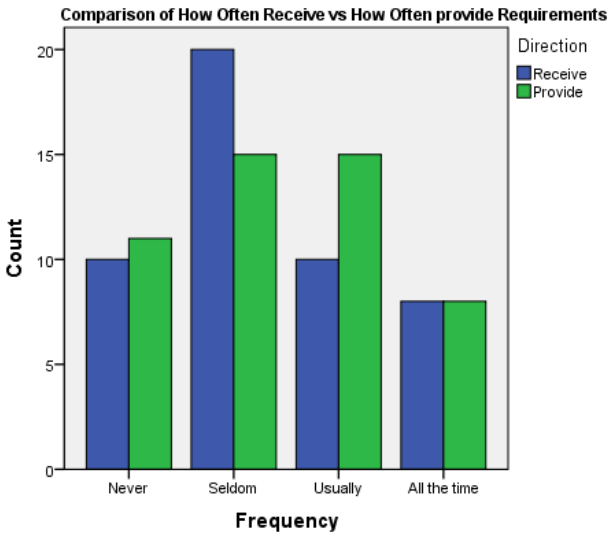

Figure 16. Comparison of how often practitioners receive vs. how often they provide requirements.

Table 17 indicates the mean ranks for both how often (frequency) practitioners receive and provide requirements. As the assumptions were fulfilled (see Appendix B), a Mann-Whitney U test was employed to find answers to the questions stated in the previous paragraph. Table 18 and Table 19 presents the values of the test and the resultant summary of the null hypothesis. It can be seen that no significance was found (p=0.674). Consequently with this statistical analysis, it can be concluded that in Open Innovation there is not significant

difference between how often practitioners receive and provide requirements among other actors in the ecosystem.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Frequency	97	2.37	1.003	1	4
Direction	100	1.50	.503	1	2

Table 16. Descriptive statistics for Frequency and Direction. Where Direction is if they receive or provide requirements and Frequency is how often it happen.

Ranks

	Direction	N	Mean Rank	Sum of Ranks
Frequency	Receive	48	47.83	2296.00
	Provide	49	50.14	2457.00
	Total	97		

Table 17. Descriptive statistics showing the mean ranks for the frequency practitioners receive requirement from other actors and provide them to others actors.

Test Statistics[a]

	Frequency
Mann-Whitney U	1120.000
Wilcoxon W	2296.000
Z	-.421
Asymp. Sig. (2-tailed)	.674

a. Grouping Variable: Direction

Table 18. Results of a Mann-Whitney U test to determine if any difference in the frequency practitioners receive and provide requirements exist.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Frequency is the same across categories of Direction.	Independent-Samples Mann-Whitney U Test	.674	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 19. Hypothesis summary for a Mann-Whitney U test to determine if is any difference in the frequency practitioners receive and provide requirements

4.5 To what extent is innovativeness measured in industry (RQ1.3)

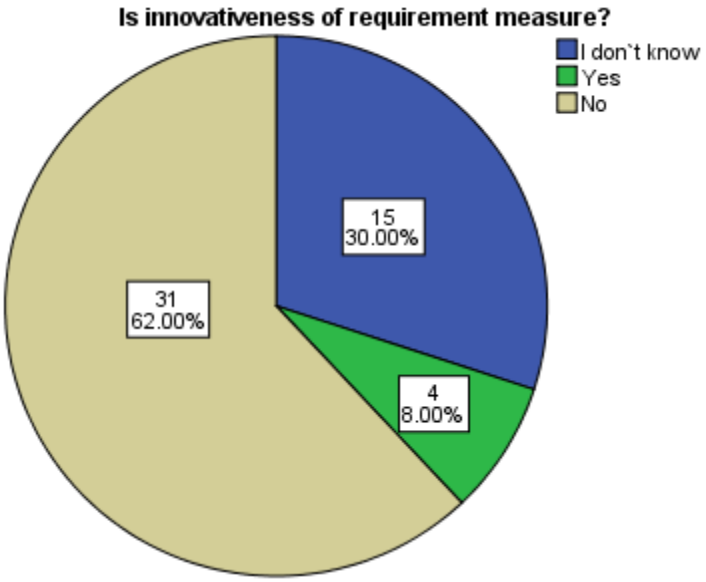

Figure 17. Distribution of respondents based on the fact of if they measure innovativeness of requirements.

This section deals with another aspect of the requirement engineering process in relation to Open Innovation. Particularly, this section aims to answer the third research sub-question (RQ1.3) regarding what extent is innovativeness of requirements measure in industry. Figure 17 visualizes the summary of the responses of the practitioners to the corresponding question in the questionnaire that inquired about this matter. From this chart, it can be seen that the majority of the practitioners (31 people, 62%) declare that they do not measure innovativeness of requirements. Surprisingly, 15 practitioners (30%) selected the "I don't know" answer while only 4 of the 50 respondents (8%) affirm they measure innovativeness of the requirement. Furthermore, the survey instrument included a free-text question inquiring about how practitioners measure innovativeness of requirements. Four answers were received. Three of them are: patents, number of created ideas, and number of new cool ideas. The fourth answers was a long explanation that did not add something new.

4.6 How Open Innovation affects decision-making (RQ2)

Turning now to the second research question (RQ2), results will be presented about how Open Innovation affects a different process of requirement engineering: decision-making, that is, prioritization and release planning. The following aspects will be considered in this section: Is innovativeness of requirements/features considered as an input for prioritization? Is innovativeness one of the most important criteria? How do practitioners decide about including a feature for the next release in an Open Innovation setting? Do practitioners consider prioritization and release planning more difficult when it comes to Open Innovation and Software Ecosystems? Is any of these aspects dependent on the role of the organization or its experience in the ecosystem?

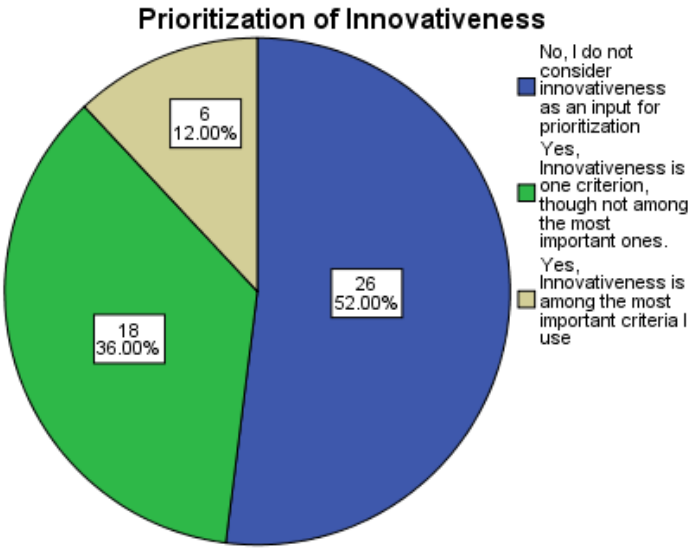

Figure 18. Distribution of respondents based on the fact of if they take into account innovativeness of requirements as an input for prioritization.

Having defined the main issues to be address in this section, let us continue and focus in the first one of them. The result obtained about the use of innovativeness as an input for prioritization are summarized in Figure 18. Slightly more than half of practitioners (26 people, 52%) answered that they do not consider innovativeness when it comes to prioritization. On the other hand, for 24 practitioners innovativeness is one criterion for prioritization. While 18 people (36%) declared it is not among the most important criteria, for 6 respondents (12%), innovativeness is one of the most important aspects to prioritize features. With the purpose of evaluate the statistical significance of these results, a Chi-Square test was employed as the assumptions were fulfilled (see Appendix B). The corresponding null hypothesis and p-value are shown in Table 20. Thus, with a p-value of 0.002, it is clear that statistical significance exists.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of PrioInno occur with equal probabilities.	One-Sample Chi-Square Test	.002	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 20. Hypothesis summary for a Chi-Square test to determine equal probabilities of occurrence for the variable PrioInno (Prioritization of Innovativeness)

Once that this results are statistically validated, it is also worth to dig further and investigate if prioritization or not prioritization of innovative features is in relation to the role or the experience of the organization in the ecosystem. The relation with the first of the two potential influencing factors, the role, is elaborated through a contingency table and a Fisher's Exact Test. Table 21 is a correspondence table illustrating the interrelation of the role with the prioritization or not prioritization of features on the part of practitioners involved in Open Innovation. Furthermore, a summary of the Chi-Square analysis (including the Exact test) is presented in Table 22. The results show that no relation is found (p=0.331).

Correspondence Table

RoleInSECO	PrioInno			
	No, I do not consider innovativeness as an input for prioritizat	Yes, Innovativeness is one criterion, though not among the most	Yes, Innovativeness is among the most important criteria I use	Active Margin
Platform owner. (Keystone)	12	5	1	18
Platform co-owner.	6	8	1	15
Building on someone else`s platform. (Niche player)	7	5	4	16
Active Margin	25	18	6	49

Table 21. Correspondence table showing the interrelation of the role of the organization in the ecosystem and the fact of taking into account innovativeness of requirements as an input for prioritization

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	7.215[a]	6	.301	.310		
Likelihood Ratio	7.141	6	.308	.363		
Fisher's Exact Test	6.890			.331		
Linear-by-Linear Association	1.934[b]	1	.164	.204	.102	.036
N of Valid Cases	50					

a. 6 cells (50.0%) have expected count less than 5. The minimum expected count is .12.

b. The standardized statistic is 1.391.

Table 22. Summary of a Chi-Square test to determine statistical significance regarding differences in the role of the organization in relation to the fact of considering innovativeness of requirement as an input for prioritization.

Likewise, the experience of the organization in the ecosystem was analyzed as a potential influenting factor on the fact of taking into account innovativeness of requirements/features as an input for prioritization. Such analysis, as in the case of the role, was performed with a correspondence table (Table 24) and the related Fisher's Exact test (Table 23). Here, no dependency was found either (p=0.669).

Thus, based on the descriptive statistics and the tests used in analyzing this first issue (the innovativeness in prioritizing) it is safe to say that even though almost half of the practitioners take into account innovativeness of features for prioritization, this pattern does not seem to depend neither on the role of the organization nor on its level of experience in the ecosystem.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	4.230[a]	6	.646	.675		
Likelihood Ratio	4.248	6	.643	.744		
Fisher's Exact Test	4.233			.669		
Linear-by-Linear Association	.039[b]	1	.843	.922	.461	.077
N of Valid Cases	50					

a. 7 cells (58.3%) have expected count less than 5. The minimum expected count is .96.

b. The standardized statistic is .198.

Table 23. Summary of a Chi-Square test to determine statistical significance regarding differences in the experience of the organization in relation to the fact of considering innovativeness of requirement as an input for prioritization.

Correspondence Table

	PrioInno			
YearsCompInSECO	No, I do not consider innovativeness as an input for prioritizat	Yes, Innovativeness is one criterion, though not among the most	Yes, Innovativeness is among the most important criteria I use	Active Margin
less than 1 year	4	3	1	8
2-3 years	8	7	1	16
4-5 years	7	6	1	14
more than 5 years	7	2	3	12
Active Margin	26	18	6	50

Table 24. Correspondence table showing the interrelation of the experience of the organization in the ecosystem and the fact of taking into account innovativeness of requirements as an input for prioritization

Another important topic to consider, in relation to decision-making in an Open Innovation context, is how practitioners proceed with release planning in such an open environment. In particular how they interact or not with other actors in the ecosystem when it comes to make a decision about including or not a feature for the next release.

The survey instrument was designed to allowed respondents to indicate how often (the frequency) they proceed with three different, mutual-exclusive alternative regarding decision-making. The frequency was on a scale of 6 different values from never to always while the different mutual-exclusive alternative, regarding the inclusion of a feature for the next release, were: "We make the decision internally without intervention of other actors", "We make an agreement with other actors in the ecosystem", "We just endorse the decisions made by other actors in the ecosystems".

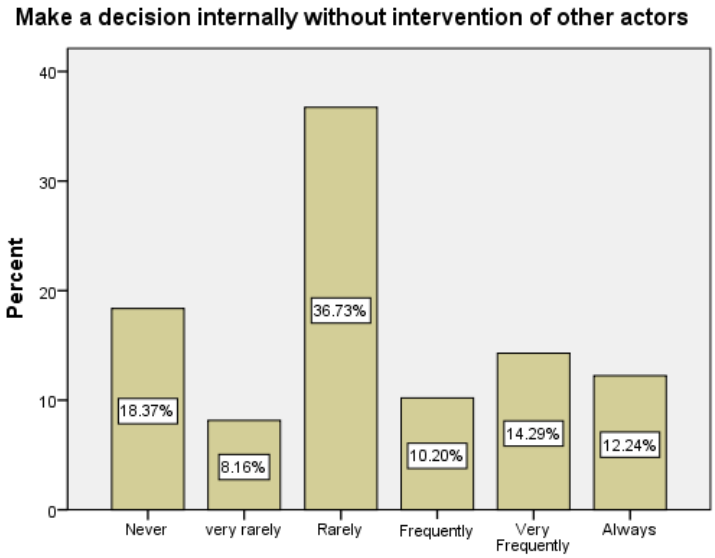

Figure 19. How often practitioners make a decision about including a feature for the next release without intervention of other actors in the ecosystem.

The charts summarizing the answers for the three alternatives are presented in Figure 19, Figure 20, and Figure 21 respectively. Remarkably, it can be observed that approx. 37% of the practitioners rarely make a decision without intervention of other actors. As it can be seen in Table 25 for every one of the three cases a Chi-Square was run in order the determine statistical significance of the results, which indeed, was found (see Table 25 for p-values and more details).

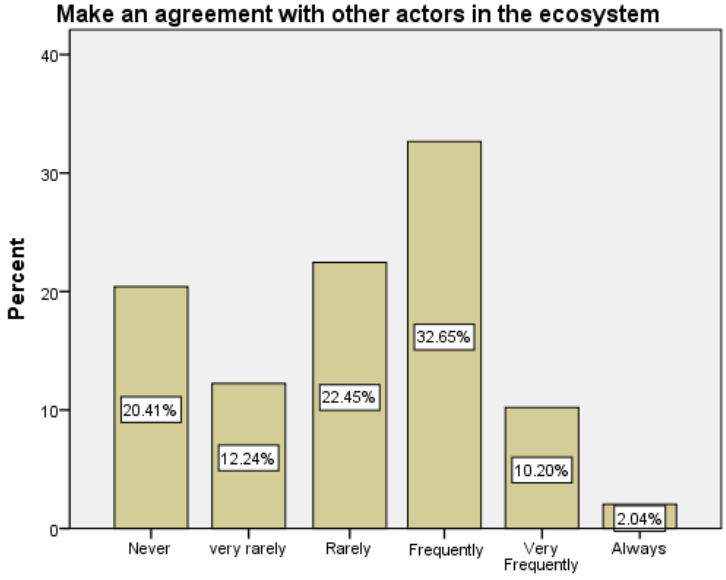

Figure 20. How often practitioners make a decision about including a feature for the next release in agreement with other actors in the ecosystem.

These results (see Figures 19-21) while interesting, do not say too much in themselves. Probably the most relevant investigation here is to discover if any of this possible options of interaction in decision-making are in connection with the role or the experience of the organization. A Correspondence Analysis [45] was selected here to perform such an

examination. The role of the organization was studied in first place as a potential influencing factor. The Fisher's Exact Value and significance are summarized in Table 26 for every one of the three possible ways to decide about including a feature for the next release. As the summary shows, no significance was found in relation to the role (p>0.05 in all cases).

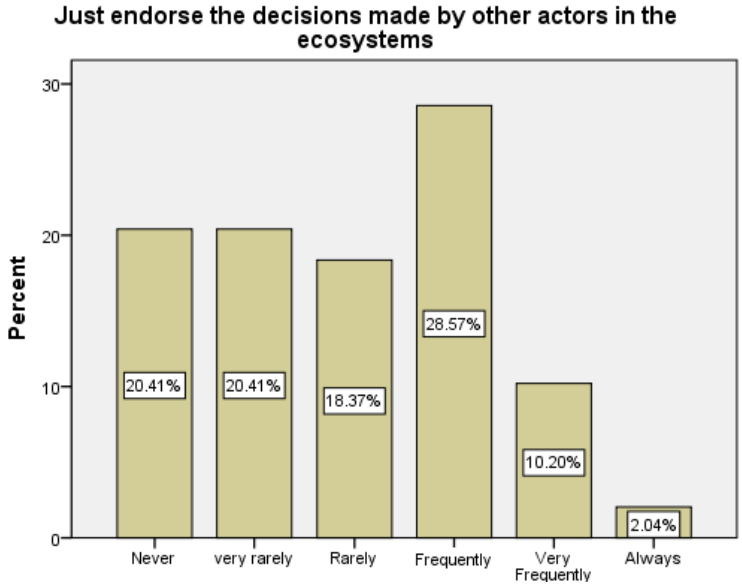

Figure 21. How often practitioners make a decision about including a feature for the next release just by endorsing the decisions made by other actors in the ecosystems.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of DecisionFeature: We make the decision internally without intervention of other actors occur with equal probabilities.	One-Sample Chi-Square Test	.007	Reject the null hypothesis.
2	The categories of DecisionFeature: We make an agreement with other actors in the ecosystem occur with equal probabilities.	One-Sample Chi-Square Test	.004	Reject the null hypothesis.
3	The categories of DecisionFeature: We just endorse the decisions made by other actors in the ecosystems occur with equal probabilities.	One-Sample Chi-Square Test	.028	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 25. Result of Chi-Square tests to determine the probabilities of equal frequencies for three different ways practitioners decide about including features for the next release.

With the purpose of showing further details, the complete Correspondence Analysis [45] is presented for the interrelation of the role of the organization in the ecosystem and one of the ways practitioners decide about including features for the next release: Internal decision without intervention of other actors (the first row in Table 26). Furthermore, in order to have an indication of the strength for this case, a measure of association was analyzed with a Cramer's V. Thus, it was found that a moderate effect size exists (Cramer's V = 0.447), though not statistical significance to determine a relationship (see Table 26 first row). More details are presented: Table 27 is the correspondence table while Table 28 shows the resultant statistical test. Moreover, a correspondence analysis plot is depicted in Figure 22.

	Fisher's	Sig.
We make the decision internally without intervention of other actors	16.118	0.052
We make an agreement with other actors in the ecosystem	7.37	0.790
We just endorse the decisions made by other actors in the ecosystems	14.601	0.099

Table 26. Summary of Fisher's Exact Value and significance regarding differences in the role of the organization in the ecosystem in relation to three different ways practitioners decide about including features for the next release.

Correspondence Table

	DecisionFeature: We make the decision internally without intervention of other actors						
RoleInSECO	Never	very rarely	Rarely	Frequently	Very Frequently	Always	Active Margin
Platform owner. (Keystone)	4	0	7	1	4	2	18
Platform co-owner.	4	0	8	0	1	2	15
Building on someone else`s platform. (Niche player)	1	4	3	4	2	2	16
Active Margin	9	4	18	5	7	6	49

Table 27. Correspondence table for the role of the organization in the ecosystem and the fact that the organization decides or not internally, the inclusion of features for the next release.

Summary

					Proportion of Inertia		Confidence Singular Value	
Dimension	Singular Value	Inertia	Chi Square	Sig.	Accounted for	Cumulative	Standard Deviation	Correlation 2
1	.601	.362			.903	.903	.102	.009
2	.197	.039			.097	1.000	.130	
Total		.400	19.611	.033[a]	1.000	1.000		

a. 10 degrees of freedom

Table 28. Summary of a Chi-Square test to determine statistical significance regarding differences in the role of the organization in relation to making a decision Internally without intervention of other actors.

Figure 22, provide an overall picture of the association of the role of the organization in the ecosystem and the fact that the organization decide or not internally, without intervention of other actors, the inclusion of features for the next release. This Figure 22 is a plot based on a Correspondence Analysis (CoAn)[45], which main purpose, in general terms, is to describe the associations between two categorical variables in a contingency table. Basically, the values of the variables are projected as points on a plot formed by two dimensions, in this way, the place the points are located describe the relationships between the categories of each variable. Thus, for each variable, the more similar categories are, the closer they are plotted to each other while, on the other hand, points that are distant show unlikeness. The values for the coordinates in the axis of the two-dimensional plot represent measurements of distance and are calculated based on the Chi-Square statistics [45].

The correspondence Analysis plot in Figure 22 would suggest that platform owners seem to make decisions on their own very frequently while those that built on someone else platform (niche players) frequently or very rarely act unilaterally. Platform co-owners never or rarely make a decision about a new feature to be released without intervention of other actors. Interestingly, the "Always" category is somewhat close to the platform co-owner role.

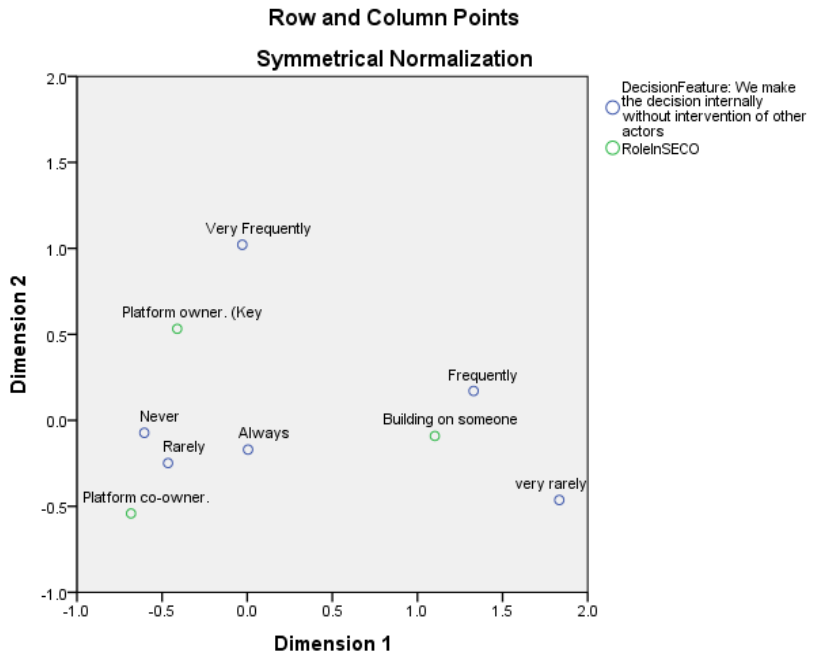

Figure 22. CoAn Plot for the role of the organization in the ecosystem and the fact that the organization decides or not internally, the inclusion of features for the next release.

Now that conclusions have been made about the dependency of the role on the decision-making process, let us continue proceed with a similar analysis but this time aiming to reveal any potential influence of the experience of the organization in the ecosystem towards the decision-making in Open Innovation.

A correspondence tables [45] were created for the interrelation of the experience with the three different options of decision-making shown in Table 29. Looking at the Fisher's Exat value and Significance in this table, it can be seen that only one association exists (see Table 29, first row). The association is confirmed by the p-value of 0.048 ($p<0.05$) for the experience of the organization in relation to the frequency when it comes to making a decision about including a feature for the next release without intervention of other actors (Table 29, first row). With the purpose of digging further and understand better this case, Table 30 and Table 31 presents the correspondence table and the test summary for this particular case. Furthermore, the correspondence analysis plot is shown in Figure 23.

	Fisher's	Sig.
We make the decision internally without intervention of other actors	20.888	0.048
We make an agreement with other actors in the ecosystem	13.012	0.613
We just endorse the decisions made by other actors in the ecosystems	13.678	0.545

Table 29. Summary of Fisher's Exact values and significance regarding differences in the experience of the organization in the ecosystem in relation to three different ways practitioners decide about including features for the next release

Correspondence Table

YearsCompInSECO	DecisionFeature: We make the decision internally without intervention of other actors						
	Never	very rarely	Rarely	Frequently	Very Frequently	Always	Active Margin
less than 1 year	3	1	2	0	0	2	8
2-3 years	3	0	9	1	3	0	16
4-5 years	1	3	6	1	1	2	14
more than 5 years	2	0	1	3	3	2	11
Active Margin	9	4	18	5	7	6	49

Table 30. Correspondence table showing the interrelation of the experience of the organization in the ecosystem and one of the ways practitioners decide about including features for the next release: Internal decision without intervention of other actors.

Summary

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Correlation 2
1	.471	.221			.467	.467	.111	-.057
2	.412	.170			.358	.825	.099	
3	.288	.083			.175	1.000		
Total		.474	23.234	.079[a]	1.000	1.000		

a. 15 degrees of freedom

Table 31. Summary of a Chi-Square test to determine statistical significance regarding differences in the experience of the organization in relation to one of the ways practitioners decide about including features for the next release: Internal decision without intervention of other actors.

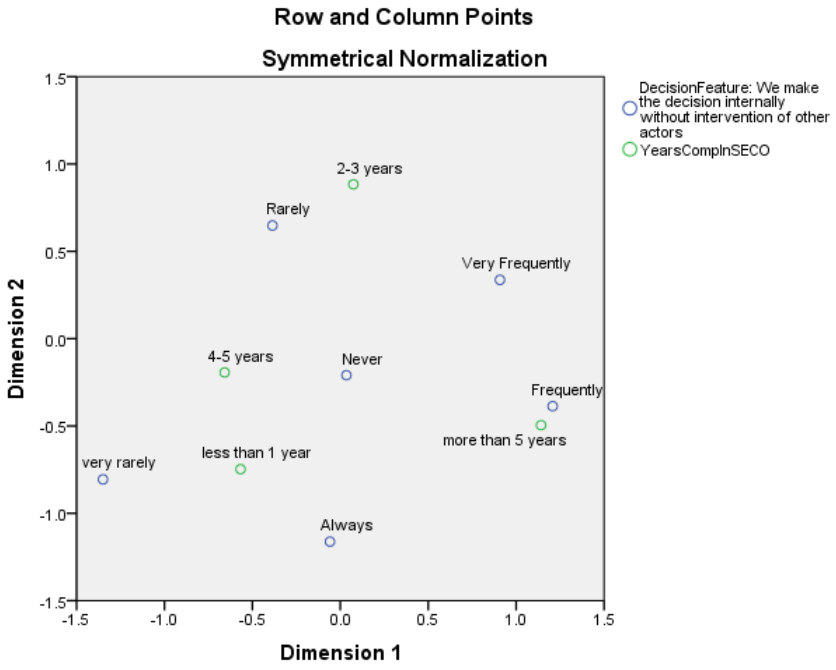

Figure 23. CoAn Plot showing the interrelation of the experience of the organization in the ecosystem and one of the ways practitioners decide about including features for the next release: Internal decision without intervention of other actors.

As pointed out at the beginning of this section, several aspects are analyzed in order to answer RQ2 regarding decision-making in Open Innovation. Having investigated innovativeness as an input for prioritization and the decision-making about including feature for the next release, let us continue with the last aspects in this section, the level of difficulty of prioritization and release planning in the context that is the subject of this study. Do practitioners consider prioritization and release planning more difficult when it comes to Open Innovation and Software Ecosystems?

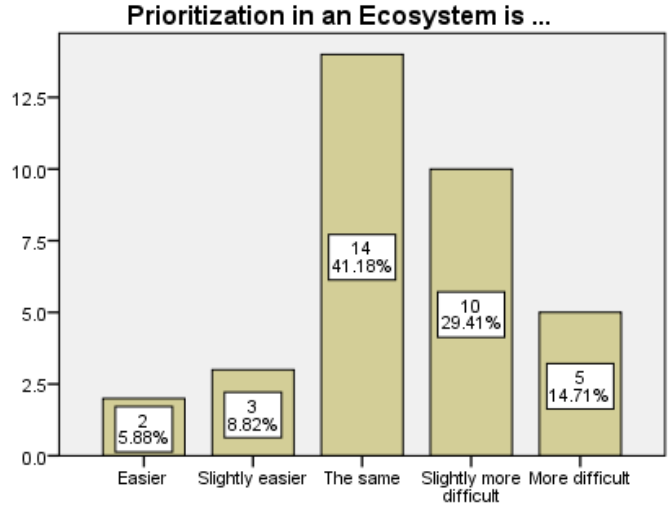

Figure 24. Level of difficulty of prioritizing requirements in an ecosystem contra a no ecosystem context.

Before proceeding to examining the results it is necessary to indicate that, as previously mentioned in Section 4.2, only those that declared to have experience in both contexts ecosystem and no ecosystem (34 practitioners) could answer the question, for more details see Figure 6 in the last part of sub-section 4.1 Respondents demographics.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of ReqSECOMoreDiff: Prioritization occur with equal probabilities.	One-Sample Chi-Square Test	.004	Reject the null hypothesis.
2	The categories of ReqSECOMoreDiff: Release planning occur with equal probabilities.	One-Sample Chi-Square Test	.248	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 32. Result of Chi-Square tests to determine the probabilities of equal frequencies for prioritization and release planning in an ecosystem.

After that important clarification, let us analyze, prioritization in the first place, that is, how difficult practitioners consider prioritization in the given context. Figure 24 gives a summary of the frequencies that practitioners categorized the difficulty of prioritization of requirements in an ecosystem vs. doing it in a no ecosystem context. For 14 of 34 respondents (Approx. 41%) is the same level of difficulty. While 5 people (Approx. 15%) considered prioritization

in an ecosystem easier or slightly easier, 15 people (Approx. 45%) considered it slightly more difficult or more difficult. This descriptive statistic, illustrated in the graphic, shows a clear inclination to the idea that prioritization in an ecosystem has the same difficulty or it is more difficult than in a no ecosystem context. A Chi-Square test was used to determine statistically if this perceived difference has significance. Table 32 shows the result in the first row, confirming the statistical significant of the results (p=0.004).

Once prioritization was analyzed, released planning is put into investigation to determine if practitioners consider it more difficult when it comes to Open Innovation and Software Ecosystems. As shown in Figure 25, 9 respondents (Approx. 26%) answered that it is the same level of difficulty. The minority (7 people, Approx. 21%) considered release planning in an ecosystem easier or slightly easier, and 16 people (Approx. 53%) considered it slightly more difficult or more difficult. Thus, 27 of 34 respondents said that release in an ecosystem has the same difficulty or it is more difficult than in a no ecosystem context. This showed a similar pattern as in the case of prioritization, nevertheless, further statistical analysis in the form of a Chi-Square determine that there is not significance difference in the occurrence of the level of difficulties when it comes to the data answered for release planning. Table 32 shows this result in the second row (p=0.248).

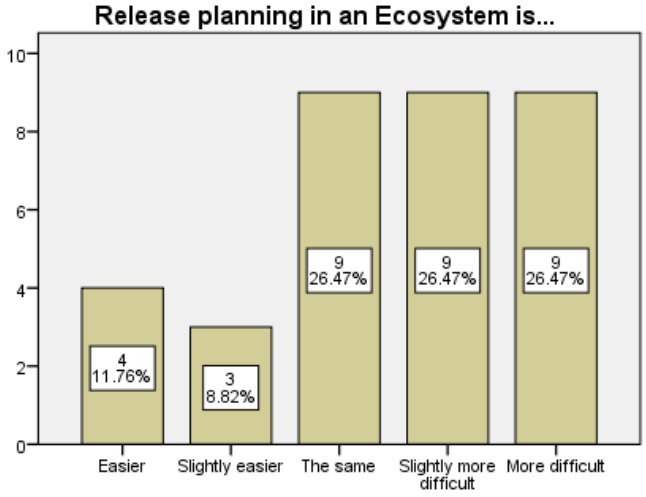

Figure 25. Level of difficulty of release planning in an ecosystem contra a no ecosystem context.

One important additional consideration is to investigate if the potential influencing factors, previously used in analyzing results, have any relation in this case. In other words, is the level of difficulty of prioritization or release planning in an ecosystem influenced by the role or level of experience of the organization? This topic is addressed in the following paragraphs.

	Role in the Ecosystem		Experience in an Ecosystem	
	Fisher's	Sig.	Fisher's	Sig.
Prioritization difficulty	11.676	0.088	10.821	0.489
Release planning difficulty	7.324	0.527	6.409	0.971

Table 33. Summary table showing the Fisher's Exact value and significance for the correlation of the role and level of experience of the organization with the level of difficulty of prioritization and release planning

With the purpose of discovering any possible association of the aforementioned influencing factors with the level of difficulty of prioritization and release planning, Contingency tables were employed. Table 33 presents a summary of the results for the four different analyzes performed for the corresponding combination. As a sample of such analyzes, a complete data for the first case (the interrelation of the experience of the organization in the ecosystem and the level of difficulty of release planning) is presented in Table 34 (Correspondence Table), Table 35 (Summary of a Chi-Square/Fisher's test), and Figure 26 (CoAn Plot). As it can be seen in Table 33, no significance was found for the influential factors (Role and Experience of the organization in the ecosystem) neither for the level of difficulty of prioritization nor for the level of difficulty in release planning.

Correspondence Table

	ReqSECOMoreDiff: Release planning					
YearsCompInSECO	Easier	Slightly easier	The same	Slightly more difficult	More difficult	Active Margin
less than 1 year	1	1	2	1	1	6
2-3 years	0	1	3	2	3	9
4-5 years	1	1	2	2	3	9
more than 5 years	2	0	2	4	2	10
Active Margin	4	3	9	9	9	34

Table 34. Correspondence table showing the interrelation of the experience of the organization in the ecosystem and the level of difficulty of release planning.

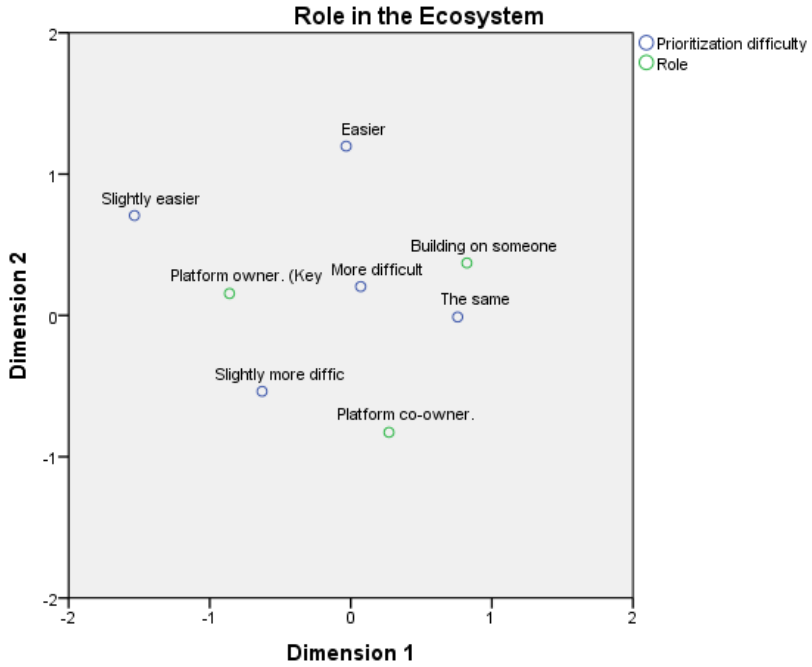

Figure 26. CoAn Plots showing the interrelation of the role of the organization in the ecosystem with the level of difficulty of prioritizing requirements.

Overall, the results in this section suggest that prioritization and release planning (specially the first one) tend to be more difficult in an ecosystem compare with a no ecosystem contexts but this does not seem to be related to the role or the experience of the organization in the Ecosystem.

Summary

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Correlation 2
1	.332	.110			.697	.697	.142	-.268
2	.195	.038			.240	.937	.171	
3	.100	.010			.063	1.000		
Total		.158	5.383	.944[a]	1.000	1.000		

a. 12 degrees of freedom

Table 35. Summary of a Chi-Square test to determine statistical significance regarding differences in the role of the organization in relation to the level of difficulty of release planning.

4.7 Innovative Outcome

So far, this result section of the paper has presented the answers to the two first research question regarding Open Innovation and Software Ecosystem in elicitation of requirements (RQ1) and decision-making (RQ2). The current section will discuss the third and fourth research question (RQ3 and RQ4) concerning to what extent Open Innovation leads to innovative requirements. Two sides of Open Innovation will be addressed in order to answer this research question: the inbound side with received requirements and the outbound side with provided requirements. For every case, both ideas and artifacts will be analyzed. Additionally, as in the previous research questions, two influencing factors, the role and experience of the organization in the ecosystem, will be investigated in order to reveal any potential association. Though, before that, a brief overall view of the answers is presented.

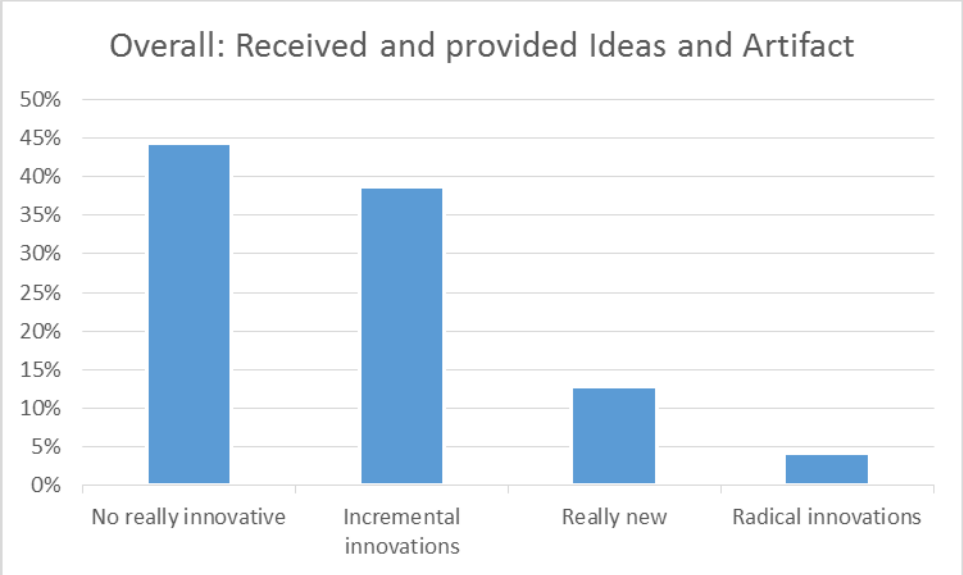

Figure 27. Chart compilation showing the percentage of how innovative practitioners consider received and provided ideas and artifacts

Figure 27 shows that, in general, an important number of people (average of 44%) think that ideas and artifacts flowing among the actors in the ecosystem are not really innovative. In average, 39% of practitioners consider them as incremental innovations, 13% think they are really new while 4% deem them as radical innovations.

4.7.1 To what extent received requirements are innovative (RQ3)

Turning now to the analysis of the first side of Open Innovation that will be addressed in this section, the inbound side, let us consider both received ideas and received artifacts and how practitioners deem them.

Before proceeding to examine the data, it will be necessary to explain that respondents could indicate if they receive ideas or artifacts from other actors in the ecosystem or not and they could classify those ideas and artifacts according to how innovative they are.

Having provided this relevant explanation, received ideas will be analyzed in the first place. The pie chart in Figure 28 shows the distribution of the answers about if practitioners receive or not ideas from other actors outside the organization. Thus, 31 respondents (62 %) do not receive ideas while 19 (38%) do receive them from other actors in the ecosystem. When it comes to classifying those received ideas according to how innovative they are, the bar chart in Figure 29 shows that 7 of 19 respondents deemed them as no really innovative while 12 practitioners categorized received ideas as incremental innovations. Interestingly, no one classified received ideas as really new or radical innovations. It is also important to clarify that this scale of innovativeness is not meant to follow strictly Garcia's [18] definition.

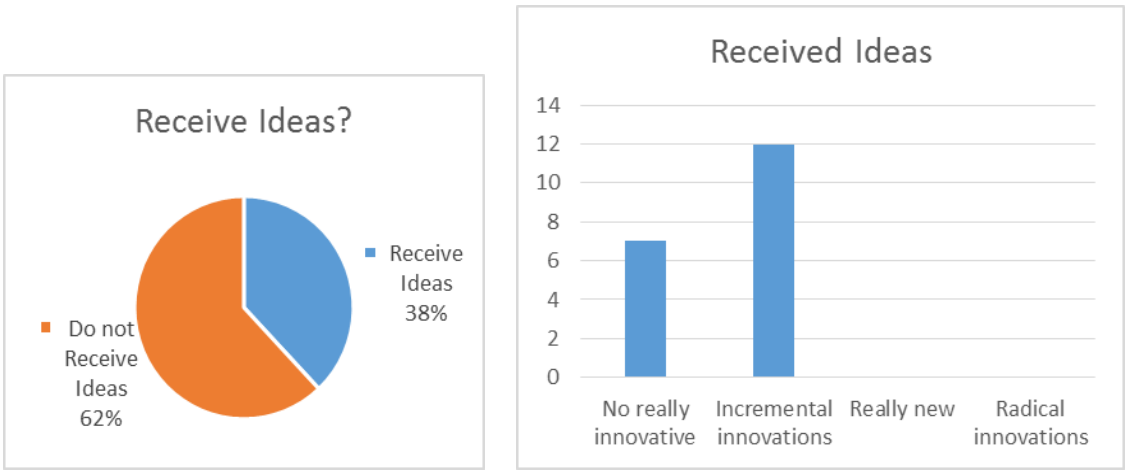

Figure 28. Chart compilation showing the percentage of practitioners receiving ideas from other actors in the ecosystem and how innovative they consider such ideas.

In relation to received artifacts, the pie chart in Figure 29 shows an identical distribution to the number of practitioners receiving artifacts compared with receiving ideas. This is, 31 respondents (62 %) do not receive artifacts while 19 (38%) do receive them from other actors in the ecosystem, such as it happens with ideas. Concerning how innovative those received artifacts are, the bar chart in Figure 29, in this case, shows that it is different from received ideas. For 10 of 19 respondents such artifacts are not really innovative, 5 practitioners deemed them as incremental innovation while 4 respondents categorized artifacts as really new, no one classify received artifacts as radical innovations.

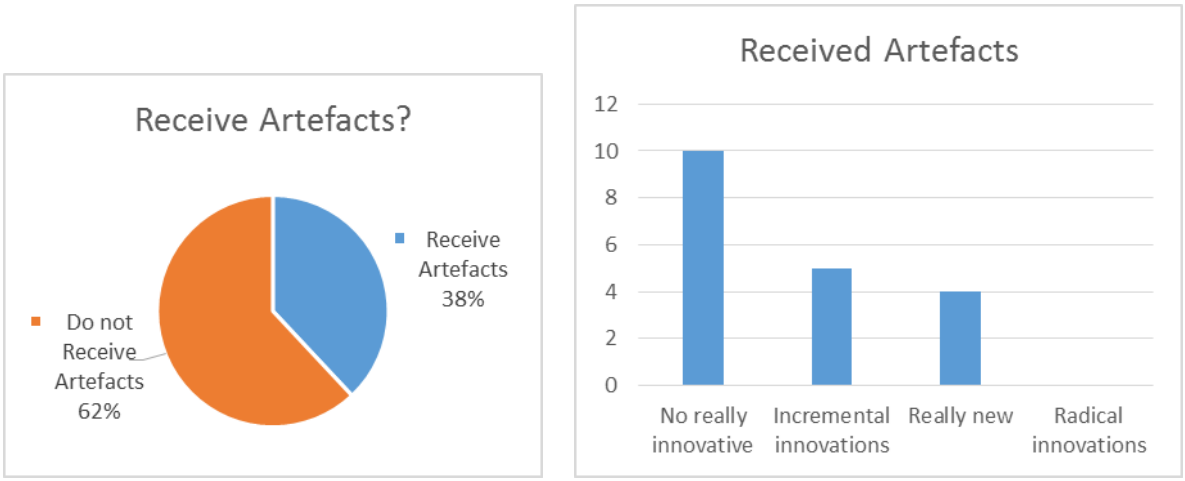

Figure 29. Chart compilation showing the percentage of practitioners receiving artifacts from other actors in the ecosystem and how innovative they consider such artifacts.

Moving forward in the analysis of results, there are more interesting aspects to consider: is the level of innovativeness of received ideas and artifacts dependable on the role or the experience of the organization in the ecosystem? In order to answer this question, contingency tables with Fisher's Exact tests were conducted to determine any association. The summary of the Fisher's values and the Significance are shown in Table 36. As it can be seen in the table, the level of innovative of receive ideas might depend on the role of the organization in the Ecosystem. Furthermore, in order to have an indication of the strength of the relation, a measure of association was analyzed with a Cramer's V. Thus, it was found that a very weak effect size exists (Cramer's V = 0.015).

	Role in the Ecosystem		Experience in an Ecosystem	
	Fisher's Value	Sig.	Fisher's Value	Sig.
Ideas	8.111	0.018	5.036	0.174
Artifacts	5.530	0.246	6.647	0.333

Table 36. Summary of Fisher's Exact values and significance regarding differences in the role and experience of the organization in the ecosystem in relation the innovativeness of ideas and artifacts they receive

4.7.2 To what extent provided requirements are innovative (RQ4)

After the previous analysis of the inbound side of Open Innovation regarding innovativeness of received ideas and artifacts, it is time to continue with the outbound side. In this section, a similar analysis is performed with ideas and artifact that practitioners provide to other actors in the ecosystem. Likewise with received ideas and artifacts, respondents could indicate if they provide ideas or artifacts to other actors in the ecosystem or not, and they could classify those ideas and artifacts they provide according to how innovative they are. From the pie chart in Figure 30 can be seen that the majority of practitioners (37 people, 74%) declared providing ideas to others outside the organization while 13 respondents (26%) affirmed they do not provide ideas to other actors.

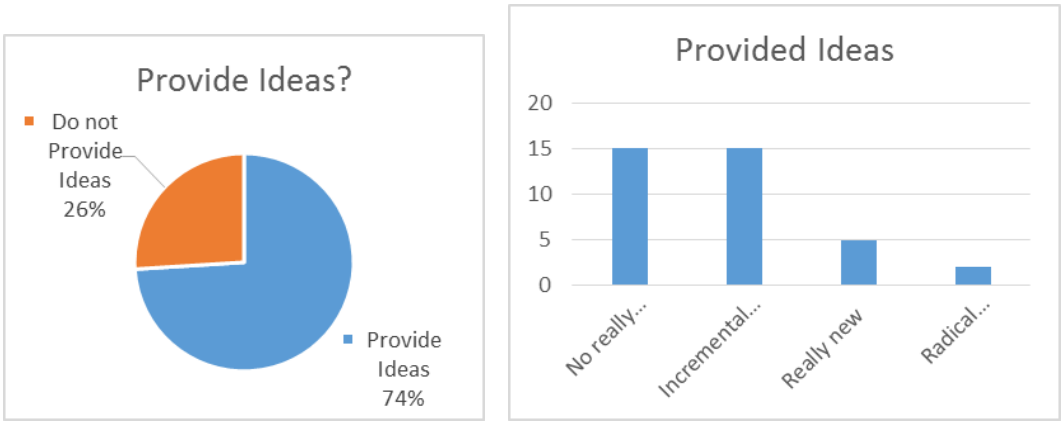

Figure 30. Chart compilation showing the percentage of practitioners providing ideas to other actors in the ecosystem and how innovative they consider such ideas.

When it comes to how innovative ideas are classified, the bar chart in Figure 30 provides an overall visualization of the opinions of respondents. For 15 people, the provided ideas are not really innovative. The same number of respondents (15 people) categorized provided ideas as incremental innovations. 5 practitioners considered provided ideas as really new while only 2 respondents classified them as radical innovations.

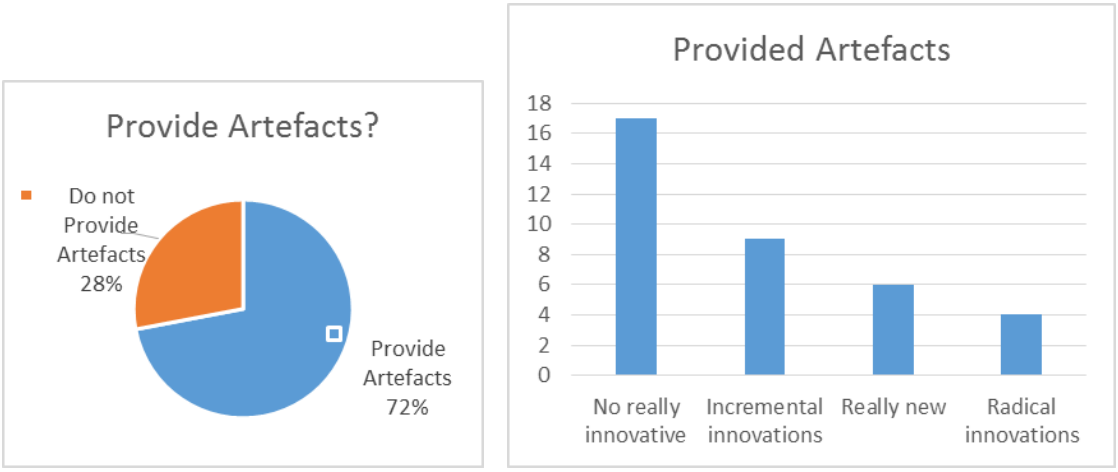

Figure 31. Chart compilation showing the percentage of practitioners providing artifacts to other actors in the ecosystem and how innovative they consider such artifacts

In the case of provided artifacts, Figure 31 includes a pie graphic which shows that 14 people (28%) affirmed that they do not provide artifacts to other actors in the ecosystems, and 36 people (72%) do provide them to others outside their organizations. The bar chart of Figure 31 presents the distribution of answers about how practitioners categorize provided artifacts in terms of innovativeness. Of the 36 respondents, 17 stated that provided artifacts are not really innovative. For other 9 practitioners those artifacts represent incremental innovations. 6 people deemed provided artifacts as really new, and 4 people cataloged them as radical innovations.

Finally, let us consider the potential affectation of the role or the experience of the organization on the innovativeness of provided ideas or artifacts. Contingency tables with Fisher's Exact tests were employed to determine if significance exists that confirms that

either the role or the experience or both influence the level of innovativeness of provided ideas or artifacts. The summary of the results, including the Fisher's Exact value and the significance are shown in Table 37. As it can be seen in that table, no significance was found, (all $p>0.05$).

	Role in the Ecosystem		Experience in an Ecosystem	
	Fisher's Value	Sig.	Fisher's Value	Sig.
Ideas	2.906	0.924	8.003	0.518
Artifacts	2.145	0.965	9.595	0.332

Table 37. Summary of Fisher's Exact values and significance regarding differences in the role and experience of the organization in the ecosystem in relation the innovativeness of ideas and artifacts they provide.

These results indicate that the innovativeness of provided ideas and artifacts are not associated neither with the role nor the experience of the organization in the ecosystem.

Further examination and interpretation of the outcomes presented in this whole section of results could be found in the following section, discussion.

5

Discussion

This section discusses the findings presented in the previous section about the requirement engineering process in Open Innovation (OI) and Software Ecosystems (SECO). Likewise the result section, this part of the document is structured according to the research questions presented in Section 3. Thus, Sections 5.1, 5.2, and 5.3 address the first research question with its three sub-questions concerning elicitation process, the received and provided requirements, and to what extent is innovativeness measured in the industry. Next, Section 5.4 deals with the second research question regarding decision-making. Finally, the third and fourth research questions are discussed at the end in Section 5.5.

5.1 Open Innovation to elicit requirements (RQ1)

The findings shows that in an open setting, such as the one investigated in the present study, requirements are elicited mainly from either both internal and external stakeholders or only external; a minority elicits requirements only from internal stakeholders. This result makes sense in Open Innovation and Software Ecosystem. In the case of Open Innovation, it could be connected to the absorptive and multiplicative capabilities that Grassman [14] relates to the Outside-in and Inside-out processes of open innovation. Thus, a possible explanation why a minority only elicit requirement from internal stakeholders can be provided. Grassman points out that "many organizations lack the ability to listen to their external world and efficiently process the signals received" [14]. As assimilation of new, external information is critical for innovative capabilities [14], it could be useful to elicit requirements from both internal and external stakeholders. Consequently, organizations working with Open Innovation would tend to avoid eliciting only from internal stakeholders. In Software Ecosystems, the basic assumption of an interdependence of the actors suggest that elicitation of requirement would tend to be not only internally, but both internally and externally. In this vein, Fricker [8, 9] highlights that requirements flow is a natural and paramount process in a Software Ecosystem.

The results, also, suggest that eliciting requirements in an Open Innovation and Software Ecosystems context would be more difficult than in a close approach that manage requirement only internally in an organization. These results are inconsistent with the findings of Wnuk et al. [35] suggesting that Open Innovation makes the challenging of identifying stakeholders' needs more manageable. A plausible explanation of this

inconsistency of the results between the two studies could be the different focuses of them. While Wnuk's investigation is related to Open Innovation in conjunction with open source development, the present study focuses in Open Innovation and Software Ecosystem, as previously mentioned.

The following finding was unexpected and suggests that the level of difficulty in eliciting requirements in the studied contexts is not related to the number of years the organization is involved in the ecosystem (experience of the organization in the ecosystem). It could be argued that the more experience the organization has in the ecosystem, the less difficult it would be to elicit requirements. Nevertheless, the results do not support that conjecture, this is, the results suggest that eliciting requirement has the same difficulty no matter the number of years the organization has in the ecosystem. One possible explanation is that in Open Innovation, and particular in software industry, the change seems to be a constant factor (i.e. continuous inflow of requirements)[34], which would keep the same level of difficulty of the elicitation process through the time. Another possible explanation for the no variation of difficulty in eliciting through the time is related to the fact that as the organization has more time in the ecosystem, the ecosystem itself is evolving and growing [19, 22]. Thus, the complexity of elicitation is also incremented in a more complex ecosystem and in some way negatively compensating the benefit of experience that help to make easier the processes.

5.2 How often receives and provide requirements (RQ1.1 and RQ1.2)

Descriptive statistics in this study indicate that 42% of the respondents seldom receive requirement from others while 38% receive them usually or all the time. Additionally, the result shows that 60% of practitioners provide requirements seldom or usually. Nevertheless, no statistical significance could be found to confirm these results, this is, to confirm that the variations in the frequencies practitioners receive and provide requirement are not by chance. It seems possible that these results, suggested by the descriptive statistic aforementioned, are due to the archetypes of Open Innovation proposed by Gassmann et al. [14] This is, not all the organizations provide or receive requirement from others actors, since this interchange of information might depend on the processes of Open Innovation the organization is involved in, namely Outside-in, Inside-out or Couple process [14]. Accordingly, organizations working with an Outside-in process are more likely to receive requirements from other actors in the ecosystem. This is in line with the absorptive capacity that is needed in this case in order to integrate external knowledge that benefits the organization[15]. Additionally, the opposite happen with organizations involved in an Inside-out process, in which case the organization will be more prone to provide requirements in line with the multiplicative capacity. On the other hand, in organizations that work with a Couple process, it could be natural to receive and provide requirements simultaneously. Thus, relational capacity [14] gives the opportunity to benefit from the interaction with the network, in such a context inflows and outflows of requirements tend to be common. As not every organization plays a role related to the Couple process, instead some could opt for either sole Inside-out or sole Outside-In, there will be organizations that seldom or even never provide or receive requirement.

5.3 To what extent is innovativeness measured in industry (RQ1.3)

The result shows that the majority of the practitioners do not measure the innovativeness of requirements. This lack of measurement of innovativeness in the industry could be explained by several causes. Edison et al. [43] point out different reasons: as there is not a stable,

unified consensus that conceptualized innovation, measurement initiatives are affected; thus organization do not use even the well-known measurement frameworks [43]. Furthermore, Edison et al. [43] mention more issues in the state of the art that might cause the limited measure of innovation in the industry. For example, there is little information about putting into practice the innovation metrics proposed in the literature.

Even though the large number of practitioners do not measure innovativeness, Edison et al. [43] found that a 35.10% do measure innovation, which is, to some extent, different to the results of this study (8%). This difference between the outcomes of the studies could be explained by several factors. The study of Edison included respondents from 13 different countries even outside Europa while the present study was done in the Scandinavian countries, mainly Sweden. Additionally, the focus of Edison's study was in the software industry in general while the present study is concentrated specifically in OI and Software Ecosystem.

Another interesting result is that 30% of the practitioners do not know if the organization measure innovativeness. This is, to a degree, in line with the findings of Edison et al. [43] that 13.82% are not aware of an explicit strategy of measurement, likewise a 24.46% do not know if a measurement program exists in their organizations. A possible reason for practitioners not knowing about measurement of innovativeness in their organizations, could the problems that organizations might experience to spread knowledge and strategies among all the employees [43]

5.4 How Open Innovation affects decision-making (RQ2)

As several aspects of prioritization and release planning were considered in the study, some interesting results in this vein are discussed in this section. The results show that almost half of the practitioners take into account innovativeness of features for prioritization, what is more for some of them (12%) innovativeness is one of the most important aspects when it comes to prioritization. Even though this seem to show that practitioners are in favor of considering innovativeness when prioritizing, it cannot be overlooked that more than the half of practitioners do not bear in mind innovativeness to prioritize requirements, which could be estimated as a quite large portion since the context is Open Innovation. Nevertheless, one reason for this could be the fact that, in general, measurement of innovativeness is not spread in the software industry [43]. Thus, with difficulties to measure innovativeness it can be, also, understood why innovativeness is not taken into account in prioritization either. Consequently, this overlook of innovativeness in prioritization could be explained by the lack of measurement of innovation reported in RQ1.3 and confirmed by the study of Edison et al. [43].

Another interesting result is about how practitioners proceed with release planning in such an open environment as the focus of the present study. Approx. 63% of the practitioners rarely, very rarely, or never make a decision without the intervention of other actors. Also, it was found that the role of the organization in the ecosystem is associated with making or not these unilateral decisions. Hence, platform owners very frequently make decisions by themselves; niche players frequently or very rarely act unilaterally; while platform co-owners never or rarely decide about including a new feature in the next release without intervention of other in the ecosystem. Clearly, results suggest that platform owners are the most prone to make decisions without a direct intervention of other actors. It could, probably, be because

platforms-owners are the keystone of the ecosystem and as such are the main responsible for the future of the platform and have a huge influence on the ecosystem [19, 44]. Platform owners usually have the vision about the direction that the ecosystem should go; thus, they have to some extent freedom to decide with more autonomy. Nevertheless, communication of the vision plays a paramount role, sharing the roadmap and long-term strategy with the ecosystem will allow alignment and eventual evolution of the entire ecosystem [7, 19, 24].

Additional findings came after analyzing the level of difficulty of prioritization and release planning when it comes to Open Innovation and Software Ecosystem. The results indicate that prioritization in an ecosystem tends to have same difficulty (41%) or tend to be slightly more difficult or more difficult (44%) than in a no ecosystem context. This is in line with the findings of Wnuk et al. [35] that suggest that prioritization is more challenging in Open Innovation, but in that case in combination with open source development while in the present study the focus is OI in Software Ecosystems.

Also, results in the form of descriptive statistics seems to show that release planning tends to be harder in the investigated context, however not statistical significance could confirm this statement. This potential result would corroborate the findings of Wnuk et al. [35] about release planning being even more challenging in Open Innovation. Nevertheless, it should be considered that the study of Wnuk was related to Open Innovation and open source while the context of the present study is Open Innovation and Software Ecosystems. Additionally not statistically significant could be found in the present results to confirm that release planning is more difficult when it comes to Open Innovation and Software Ecosystems. Therefore, this is far away from being conclusive, but could point out a potential pattern that could be investigated further in future researches. Moreover, the postulation of decision-making being more challenging in Open Innovation might suggest that current methods should be adapted, or new methods and tools need to be developed specifically for this context [35, 2].

5.5 To what extent does Open Innovation lead to innovative requirements (RQ3 and RQ4)

Results about to what extent Open Innovation leads to innovative requirements include: While received ideas are not deemed as really new or radical innovations, the majority (12 of 19 practitioners) consider them as incremental innovations. For about half of practitioners (10 of 19 respondents) received artifacts are not innovative, the rest think they are either incremental innovation (5 of 19 resp.) or really new (4 of 9 resp.) but not radical innovations. These findings are to some extent disappointing, since many practitioners deem ideas and artifacts as no really innovative. Nevertheless, a possible explanation of this could be that not all the actors in an ecosystem necessarily generate innovative ideas or artifacts. Consequently, practitioners receiving ideas and artifacts from those actors that do not produce the innovative ones, naturally, would categorized them as no really innovative. On the other hand, as a considerable number of practitioners considered received ideas and artifacts as incremental innovations or really new, this means that in general innovation flows among the Software Ecosystems and eventually different actors can redeem value from them [5, 7].

An interesting data that in some way affects this result is that only about a 40% of practitioners receive ideas and artifacts from other actors in the ecosystem. In Open Innovation, there are three archetypes or processes, namely Outside-in, Inside-out and

coupled [14]. As pointed out by Grassmann [14] regarding the outside-in aspect of Open Innovation “external knowledge sourcing can increase a company’s innovativeness”. Thus, it could be argued that organizations that do not receive ideas and artifacts from other actors might be losing sources of innovation.

Regarding provided ideas and artifacts, it is interesting that the majority (Approx. 73%) provide them to others actors in the ecosystem. Now, when it comes to how innovative those ideas and artifact are, most practitioners categorized provided ideas as incremental innovations (40%) or really new (14%), and few practitioners (5%) classified them as radical innovations. About provided artifacts a considerable 11% think that are radical innovations, albeit 47% consider them as no really innovative, for the rest provided artifacts are either incremental innovation or really new. In general, it could be seen that provided ideas and artifacts are deemed to be more innovative than the received counterparts. This may be due to the fact that the own work might be overestimated. Another, possible explanation for providing ideas and artifacts more than receiving them could be the role of the organization, since approximately 2 of each 3 respondents worked in a platform owner or platform co-owner organization and they could be providing more than what they receive, in terms of ideas and artifacts, of course.

6

Conclusion

This paper set out to investigate how the requirement engineering practices are performed and how innovative the outcomes are in organizations that use Open Innovation (OI) and interact with different actors in a Software Ecosystem (SECO). Through a survey, in the form of an online questionnaire, answers were collected from 50 practitioners involved in organizations in the contexts previously described. In consequence, and more specifically, result about how elicitation and decision-making looks like in those companies were identified as well as the level of innovativeness of received and provided ideas and artifacts.

In RQ1, the aim was to discover how requirements elicitation looks like in Open Innovation and Software Ecosystems. The findings are that practitioners elicit requirements mainly from either both internal and external stakeholders or only external; a minority elicits requirements only from internal stakeholders. Additionally, 60% of the practitioners take into account a large set of stakeholders for elicitation instead of a small number of them. More than 60% of practitioners consider slightly more difficult or more difficult to elicit requirement in an ecosystem. The level of difficulty in eliciting requirements in the studied contexts is not related to the role the organization plays in the ecosystem (platform owner, platform co-owner, or niche player) nor to the number of years it is involved in the ecosystem (experience of the organization in the ecosystem). Regarding how often practitioners receive (RQ1.1) and provide (RQ1.2) requirements from other actors in the ecosystem, 42% of the respondents seldom receive requirements from others while 38% receive them usually or all the time. Additionally, descriptive statistic shows that 60% of practitioners provide requirements seldom or usually. Nevertheless, no statistical significance could be found to confirm that variations among the frequencies practitioners receive and provide requirements are not by chance. The frequency requirements are received and provided do not seem to be influenced by the role or the level of experience the organization in the ecosystem. It was also found that there is not a difference between how often they receive and provide requirements. For to what extent is innovativeness of requirements measured in industry (RQ1.3), descriptive statistics indicate that the majority of the practitioners (62%) do not measure innovativeness of requirements while only 8% affirm they measure it. The mentioned ways to measure innovativeness are: patents, number of created ideas, and number of new cool ideas. Surprisingly, 15 practitioners (30%) declared not knowing if innovativeness of requirements is measure or not.

When it comes to how Open Innovation affects decision-making (RQ2), several aspects of prioritization and release planning are considered. The results show that almost half of the

practitioners (48%) take into account innovativeness of features for prioritization including a 12% for whom innovativeness is one of the most important aspects. Albeit, this pattern does not seem to depend neither on the role of the organization nor on its level of experience in the ecosystem. Another topic investigated was how practitioners proceed with release planning in such an open environment. It could be observed that approx. 37% of the practitioners rarely make a decision without the intervention of other actors. This particular way to make a decision is dependable on the role of the organization in the ecosystem. Thus, platform owners very frequently make decisions by themselves; niche player frequently or very rarely act unilaterally; while platform co-owners never or rarely decide about including a new feature in the next release without intervention of others in the ecosystem. Concerning others way to make decisions, 43 % of the respondent frequently or very frequently make an agreement with others while 20% never make agreements. Also, Approx a 40% endorse the decisions made by other actors in the ecosystems frequently or very frequently and 20% never do that. Additionally, another aspect of decision-making, the level of difficulty of prioritization and release planning when it come to Open Innovation and Software Ecosystem, was also analyzed. The results indicate that prioritization in an ecosystem has the same difficulty (41%), or it is slightly more difficult or more difficult (44%) than in a no ecosystem context. Descriptive statistic seems to show that release planning also tends to be more difficult in the investigated context, however not statistical significance could confirm this statement. It also was found that the role of the organization and its level of experience in the ecosystem do not seem to be associated with the level of difficulty in prioritization or release planning in Open Innovation and Software Ecosystems.

In relation to the innovative outcome (RQ3 and RQ4) - To what extent does Open Innovation lead to innovative requirements, the results include: In general, as many as 44% of practitioners think that ideas and artifacts flowing among the actors in the ecosystem are not really innovative. Only about a 40% (19 of 50 practitioners) receive ideas and artifacts from other actors in the ecosystem. While received ideas are not deemed as really new or radical innovations, the majority (12 practitioners, 63%) consider them as incremental innovations. For about half of practitioners received artifacts are not innovative, the rest think they are either incremental innovation or really new but not radical innovations. Regarding provided ideas and artifacts, the majority (74% and 72% respectively) provide them to others actors in the ecosystem. Most practitioners (Approx. 54%) categorized provided ideas as incremental innovations or really new, and few practitioners (5%) classified them as radical innovations. While an 11% of practitioners think that provided artifacts are radical innovations, almost a half (47%) consider them as no really innovative, for the rest provided artifacts are either incremental innovation or really new. Additionally, the role or the experience of the organization in the Ecosystem does not seem to affect the level of innovativeness, except for a weak relation of the receive ideas with the role of the organization in the Ecosystem.

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Appendix A. Questionnaire

Page 01

Requirements Engineering in Open Collaboration

Purpose: The purpose of this study is to explore the requirements engineering practices in the industry when innovation emerges in a collaborative-open manner through Software Ecosystems. All answers will be kept confidential. No details identifying yourself or your organization will be published.

Most of the question in this survey have predefined alternatives, and it will take 10-15 minutes to complete.

Investigators: Abel Gonzalez (Master Student at Gothenburg University) and Dr. Richard Berntsson Svensson (Chalmers | University of Gothenburg)

Why you should bother: We are researchers in Software Engineering trying to understand the current practices and challenges for the requirement engineering process in new collaborative settings in the industry.

For this we need your help.

Page 02

ValidSECO

1. Is your company involved with a software platform/market in collaboration with other actors (Ecosystem, third party developers, open source communities, software vendors, etc.)?

- ○ Yes
- ○ No

Page 03

From this time on, the software platform/market and all the actors collaborating around it (your company among them) will be referred as the SOFTWARE ECOSYSTEM, or just the Ecosystem.

"A Software Ecosystem is a set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them..." (Jansen 2009)

Page 04

ValidOI

2. Would you said that your company uses both internal and external knowledge* to increase innovation and/or market?

*External knowledge: from the ecosystem, this is, the software platform/market, other actors (third party developers, open source, software vendors, etc.)

- ○ Yes
- ○ No

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3. What is your position in the organization?

- ○ Product Manager
- ○ Product Owner
- ○ Project Manager
- ○ Developer
- ○ Requirements Engineer
- ○ Business Analyst
- ○ Software Architect
- ○ Chief architect
- ○ Functional/line Manager
- ○ Other, please specify

4. How many years have you been working in the organization?

- ○ less than 1 year
- ○ 1-2 years
- ○ 3-5 year
- ○ 6-10 year more than
- ○ 10 years

5. How many years have the organization been working with a Software Ecosystem*?

*SOFTWARE ECOSYSTEM: the software platform/market and all the actors collaborating around it (including your company)

- ○ less than 1 year
- ○ 2-3 years
- ○ 4-5 years
- ○ more than 5 years
- ○ I don't know

6. How would you describe your role in the Software Ecosystem?

- ○ Platform owner. (Keystone)
- ○ Platform co-owner.
- ○ Building on someone else's platform. (Niche player)
- ○ Other, please specify ☐

7. Which categories describe your organization?

Select all that apply

- ☐ 3rd Party developer
- ☐ Start-up
- ☐ Large company
- ☐ Joint venture
- ☐ Open source
- ☐ Other ☐

8. What were the reasons or triggers to create/join the ecosystem?

☐ I don't Know

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Requirements Engineering Process

*SOFTWARE ECOSYSTEM: the software platform/market and all the actors collaborating around it (including your company)

9. How many people is directly involved in requirement engineering process in your organization?

- ○ 1-3
- ○ 4-10
- ○ 10-20
- ○ 20+
- ○ I don't know

Elicitation

10. You elicit requirements from

Select all that apply

- ☐ Internal stakeholders (within your company and your direct customers)
- ☐ External stakeholders (within the ecosystem*)
- ☐ Others

11. What describes better the number of stakeholder you elicit requirements from?

- ○ A narrow set of stakeholders
- ○ A large number of stakeholders
- ○ Other

12. Do you ...

	Never	Seldom	Usually	All the time	I don't know
receive requirements from other actors in the ecosystem?	○	○	○	○	○
provide requirements to other actors in the ecosystem?	○	○	○	○	○

13. Would you say that is more challenging to be creative/inventive when working in a Software Ecosystem*? Think in your own ecosystem context. (ex. with third-party developers, communities, etc.)

- ○ Yes In which ways? If you don't know why, just say it.
- ○ No
- ○ I don't know

14. Do you have any way to measure the innovativeness of ideas/features that have just been elicited?

- ○ Yes How do you measure the innovativeness?
- ○ No
- ○ I don't know

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Decision making

*SOFTWARE ECOSYSTEM: the software platform/market and all the actors collaborating around it (including your company)

15. Do you prioritize features/requirements according to how innovative they are?

- ○ No, I do not consider innovativeness as an input for prioritization
- ○ Yes, Innovativeness is one criterion, though not among the most important ones.
- ○ Yes, Innovativeness is among the most important criteria I use
- ○ I don't know

16. How do you make a decision about including a feature for the next release?

We make the decision internally without intervention of other actors

Never	very rarely	Rarely	Frequently	Very Frequently	Always	I don't know
○	○	○	○	○	○	○

We make an agreement with other actors in the ecosystem

Never	very rarely	Rarely	Frequently	Very Frequently	Always	I don't know
○	○	○	○	○	○	○

We just endorse the decisions made by other actors in the ecosystems

Never	very rarely	Rarely	Frequently	Very Frequently	Always	I don't know
○	○	○	○	○	○	○

17. What would you say is particularly challenging (if anything) in prioritization of req. and/or release planning in an open context (Software Ecosystem*)?

☐ I think nothing is particularly challenging

18. Have you ever worked with requirements internally, that is, requirements for products not related to the Software Ecosystem*.

- ○ Yes, I have worked with requirement internally as well.
- ○ No, I have only/always worked with requirement in an ecosystem context

Page 08

Decision making

*SOFTWARE ECOSYSTEM: the software platform/market and all the actors collaborating around it (including your company)

19. Working with requirements in an ecosystem is easier or more difficult than working only internally?

In an Ecosystem is

	Easier difficult	Slightly easier	The same	Slightly more Difficult	More difficult
Elicitation	○	○	○	○	○
Prioritization	○	○	○	○	○
Release planning	○	○	○	○	○

Page 09
InnOutcome1

Innovation outcome

20. Do you RECEIVE ideas or artifacts from outside of your organization? Artifacts ex: Mockups, prototypes, plugins, etc.

○ Yes
○ No
○ I don't know

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InnOutcome2

Innovation outcome

21. How would you classify these ideas and/or artifact you RECEIVE?

	No really Innovative	Incremental innovations	Really new	Radical innovations	We do not receive this
Ideas	○	○	○	○	○
Artifacts	○	○	○	○	○

22. Can you shortly provide whatever examples you can come up with from the top of your mind?

Ideas (Received)	
Artifacts (Received)	

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InnOutcome3

Innovation outcome

23. Does your organization <u>PROVIDE</u> external actors with ideas or actifacts? Artifacts ex: Mockups, prototypes, plugins, etc.

- ○ Yes
- ○ No
- ○ I don't know

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InnOutcome4

Innovation outcome

24. How would you classify these ideas and/or artifact you PROVIDE to others?

	No really Innovative	Incremental innovations	Really new	Radical innovations	We do not receive this
Ideas	○	○	○	○	○
Artifacts	○	○	○	○	○

25. Can you shortly provide whatever examples you can come up with from the top of your mind?

Ideas (provided)

Artifacts (provided)

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ScreenOut

Thank you for completing this questionnaire!

Unfortunately, at this time your profile does not fit our criteria

You may close the browser window or tab now.

We would like to thank you very much for helping us.

Last page

Thank you for completing this questionnaire!

We would like to thank you very much for helping us.

Your answers were transmitted, you may close the browser window or tab now.

Abel Gonzalez, University of Gothenburg – 2015

Appendix B. Assumptions of Statistical Test

Chi-Square Test.

No more than 20% of the expected counts are less than 5 and all individual expected counts are 1 or greater [46]

Fisher's Exact Test

Each observation is classified into exactly one cell, the row and column totals are fixed, not random

Kolmogorov-Smirnov Test

"Exact control over the probability of a Type I error can be had assuming random sampling only. When there are no tied values, the method in Kim and Jennrich (1973) can be used to compute the exact probability of a Type I error. With tied values, the exact probability of a Type I error can be computed with a method derived by Schro¨er and Trenkler (1995)".[47]

Mann-Whitney U Test

One dependent variable that is measured at the continuous or ordinal level. One independent variable that consists of two categorical, independent groups. Independence of observations. Determine whether the distribution of scores for both groups of your independent variable have the same shape or a different shape.

Correspondence Analysis (CoAn)

Same as Chi-Square Test.

Cramer's V Test.

Same as Chi-Square Test.