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Factors that affect developers' decision to participate in a Mobile Software Ecosystem☆

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ABSTRACT

In Mobile Software Ecosystem (MSECO), external developers build applications that meet the interest of users of mobile technologies. Researchers claim that MSECO sustainability depends on two capabilities: adoption of new technologies over time, and attraction and maintenance of people (i.e., developers and users) participating in these ecosystems. Our research focuses on the latter. We investigated factors that affect developers' decision to participate in an MSECO. First, we analyzed the literature to identify such motivational factors. Second, we interviewed experts in MSECO aiming to refine the identified factors. Finally, we also conducted interviews to identify the opinion of MSECO developers regarding the refined list of factors. The final list of 29 factors were discussed, one by one, by the 20 interviewees. Each developer indicated which factor motivated him/her to join a certain MSECO and also which has kept him/her contributing to it. Results indicate that the lack of studies focusing on developers, not just on technologies or business rules of the ecosystem, is a key for understanding developers' decision to participate in an MSECO. Moreover, developers become more concerned with their relationships in these ecosystems over time. As such, ou research contributes to the MSECO field with a list of motivating factors that should be considered by external developers from ecosystems towards MSECO sustainability.

1. Introduction

Software Ecosystems (SECO) are complex systems in which the current software solutions are been developed in. SECO are composed by internal and external developers, i.e., a community of domain experts that aims to meet the demands of a end-user community. In these ecosystems, developers are responsible for building the software solutions that meet the demands of these end-users (Bosch and Bosch-Sijtsema, 2010).

Mobile SECO (MSECO) are SECO focused on a mobile context (Fontão et al., 2015), i.e., ecosystems that aims to produce applications for mobile devices (e.g., smartphones). This kind of SECO has two great market leaders: Google (Android) and Apple (iOS) (Mallinson, 2015). Given the growing use of mobile applications around the world, MSECO sustainability becomes a key element to the ecosystem health (Costa et al., 2021). Such sustainability depends on two capabilities: of an ecosystem to adapt itself, when necessary, to new technologies and resources; and of attracting and retaining actors who are interested in contributing to the ecosystem (Dhungana et al., 2010).

Some studies present a set of factors that can affect a developer's decision to adopt an MSECO (Koch and Kerschbaum, 2014). Such adoption refers to the act of a developer decide to start contributing to an MSECO (Sadi et al., 2015). An MSECO developer may have his/her motivations changing over time. Thus, some studies have focused on the adoption of an MSECO (Koch and Kerschbaum, 2014), while others refer to the factors that impact the permanence of these developers (Ryu et al., 2014). Permanence or continuance refers to the status of a developer who stays contributing to an MSECO as time goes by Ryu et al. (2014). In this research, we seek to identify the developers' perceptions from such two viewpoints — factors that affected their decisions to start contributing to an MSECO and the reasons to continue contributing to it over time.

Therefore, this article reports on an investigation of factors that may affect developers' decision to participate in an MSECO.

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To do so, we conducted a systematic mapping study aiming to identify these factors; an interview-based study with experts in MSECO to consolidate what we had found in the literature; and an interview-based study with MSECO developers to know their opinion about the identified factors. At the end, we identified 29 factors that may influence developers to join and continue contributing to an MSECO and report on how these factors affect the developers' decisions based on their experiences.

We have identified that developers become more concerned with their relationships in these ecosystems over time. Also, the most important factors for a developer to continue contributing are: (F19) To get support for the application entire life cycle; (F26) To exchange knowledge between developers and community; (F15) To have the opportunity to get a nice job; (F3) To have access to hardware with an acceptable performance; (F6) To develop applications with built-in security features provided by the platform; and (F29) To enter a large and fair community of application developers.

The reminder of this article is organized as follows: Section 2 describes the theoretical background. Section 3 presents related work. Section 4 describes the method. Section 5 reports the results while Section 6 presents a discussion. Section 7 explains the research limitations. Section 8 concludes the article with some final remarks.

2. Background

Manikas and Hansen (2013) define a SECO as a set of actors (i.e., developers and users) interacting over a common technological platform, which results in a number of solutions and services. Jansen et al. (2009) define a SECO as a set of businesses working as a unit and interacting with a market shared between software and services. On the other hand, Bosch (2009) says that a SECO is comprised of a set of software solutions that allow, support, and automate the activities and transactions of the actors within the ecosystem.

The most comprehensive definition of a SECO aligned to our research is the one presented by Bosch and Bosch-Sijtsema (2010), which defines a SECO as a software platform, an internal and external set of developers, and some domain experts in the community aiming to compose solutions to satisfy the user demands. Also, a SECO includes the software development process, commercialization (in the SECO market), and an engaged community (developer and users) actively participating in this SECO.

2.1. Software ecosystems

An SECO is comprised of three main dimensions (Campbell and Ahmed, 2010; dos Santos and Werner, 2011), namely technical, business and social. The technical dimension, also referred to as architectural, comprehends the technologies employed on the SECO as well as development patterns, resources, applications' quality, and applications' security, among other aspects. The supported programming languages and the software development kits (SDKs) that facilitate the application creation are examples.

The business dimension refers to the revenue from application sales, product lines, and market job opportunities to developers. The comparison of the profitability of two application stores and the application distribution in several countries are business aspects of a SECO.

The social dimension comprises people that belong to the SECO community, their relationships, roles they play within the ecosystem as well as the challenges they face or even their feelings about the ecosystem. Examples are the motivation that leads an actor to participate in a SECO and how an actor feels about a new technology.

2.2. Mobile software ecosystems

As previously described, an MSECO is an ecosystem that focuses on mobile solutions. Fontão et al. (2015) present the elements that comprise an MSECO, as follows:

Platform – It means the technological architecture, communication protocols, and available resources to MSECO actors. One example is the developing environment.

Users – The users are considered the most important element of an MSECO. They are the application store customers and provide feedback to MSECO developers and owners (i.e., keystones). They influence all the MSECO workflow. The number of active users of a platform expresses how they are satisfied with an MSECO.

Developers – They develop solutions to satisfy user demands, bringing innovation. These developers are categorized into internal developers, those who develop the platform, and external developers, those who create the applications.

Community – The set of actors (e.g., users, internal and external developers) within an MSECO. There are specific communities in an MSECO, such as the developers' community or the users' community.

Applications – The artifacts produced by developers to attend user demands. The applications often must attend defined quality patterns in an MSECO.

Application Stores – Similar to a marketplace, it is a place where the users can search and purchase mobile software solutions. Moreover, it is the place where developers promote the software solutions they produced. The goal is to reach the greatest number of users as possible.

Evangelists – They are users or developers who interact within an MSECO, seeking to promote the innovation over new applications. These are often community experts who are knowledgeable on the MSECO activities and operation.

2.3. Developers in mobile software ecosystems

A developer is a key element for an MSECO. The number and participation of external developers impact MSECO sustainability (Dhungana et al., 2010). Android and iOS are the most cited MSECO in literature. Mallinson (2015) indicates that these are the MSECO market leaders. Their owners, Google and Apple, respectively, want to attract and keep external developers participating in their MSECO given that they are the people who provide the services to users (customers).

An external developer can work in different contexts and settings. For instance, a developer can be an indie or an amateur developer who only wants to show his/her creativity or entrepreneurship aiming to validate a product with real users. Moreover, a developer also could sell his/her workforce to a company whose business is to develop software to another company (business-to-business), or just have an Information Technology (IT) department where developers produce applications for their own companies (Oliveira et al., 2021; Fontão et al., 2016).

Despite the importance of developers to an MSECO, de Souza et al. (2016) describe that literature has few studies on the social dimension of an ecosystem in comparison with the technical or business dimensions. As such, studies that investigate developer motivation and the factors that can affect participation in an MSECO become relevant, contributing to the literature on the social dimension.

3. Related work

The Software Engineering literature presents some studies on the topic of developers' motivation. Schoeffel et al. (2018) reports on a systematic literature review that identified motivation factors that affect undergraduate students' engagement with their studies. These factors include: prior knowledge, student–professor interaction, future aspirations, participation, having a reason to attend the program, experience, confidence, gender, behavior, learning, satisfaction/entertainment, practice/study, and independence. Al-Hinai et al. (2020) investigated some motivational factors from Oil and Gas industry professionals. They include freedom to taking initiatives, pleasure/fun, task achievement, engagement to company policy, rewards, training and development, work environment, and salary and wages.

Baddoo et al. (2006) unveiled motivation factors when investigating developers of a high-maturity company. Examples are technically challenging work, opportunities for carrier development and job promotion, payment and benefits, recognition, increased responsibility, technical support and supervision, work conditions, job security, senior management support, company policy, autonomy, and ownership. Hall et al. (2008) argued that motivation can be common among developers and centered on the individual. Individual-centered motivation factors are: working on challenging endeavors, change, benefit, problem-solving, teamwork, science, experiment, and development practices.

Beecham et al. (2008) found that software engineers are likely to be motivated according to three related factors: their characteristics (e.g., their need for stability, feedback and independence), internal controls (e.g., their personality, carrier path and competencies), and external moderators (e.g., their career stage, job type and type of organization relate to lifestyle). The authors also identified factors that can demotivate software engineers, namely: risk, stress, inequity, interesting work going to other parties, unfair reward system, lack of promotion, poor communication, uncompetitive pay/poor pay/unpaid overtime, unrealistic goals/phoney deadlines, bad relationship with users and colleagues, poor working environment, poor management, producing poor quality software, poor cultural fit/stereotyping/role ambiguity, and lack of influence/not involved in decision making/no voice.

França et al. (2011) updated the literature review conducted by Beecham et al. (2008), identifying other aspects of Software Engineering that could motivate a developer, such as development practices, technical challenge, creativity, team quality, abstract problem solving, and relationship with users and customers. Moreover, the authors explain that boredom (e.g., repetitive tasks) can demotivate a developer. In a follow-up study, the authors identified additional aspects that may affect the developers' motivation, such as tasks variety, learning, technological challenges, and autonomy (França et al., 2013). In a later work, the authors argue that motivation factors can be categorized into the following categories (França et al., 2018): the work itself (relationship between characteristics of the work), pay and benefits, recognition, promotion, working conditions, company, supervisors, and co-working.

VanAntwerp and Wilson (2018) investigated the motivation to work in mid-career on Engineering, focusing on how women perceive the matter. The authors investigate the differences between early career and mid-career women, explaining that women have more chances to become demotivated on mid-career than men given that women perceive more attractive opportunities in other fields that receive them better and offer more chances to grow.

Gerosa et al. (2021) found that motivation for developers to participate in open source projects include: ideology, altruism, fun, kinship (i.e., affinity to the cause), reputation, reciprocity, learning, own-use, career, and pay. In turn, Schaarschmidt et al. (2019) studied some differences between Android or iOS developers' motivations over the openness of the platform. The authors interviewed 31 developers and found evidences to some hypothesis, such as: the attitude of these developers is positively associate to their perception about the platform openness; the attitude for openness is stronger in developers from open platforms than those from closed platforms; developers' perception about openness is related to their intrinsic motivation; such intrinsic motivations are stronger in developers of open platforms than the developers of close platforms; an intrinsic motivation is related to the numbers of hours he/she expends working on a project; developers' perception on platform openness is associated with their willingness to take risks; and this willingness to take risks is associated to the number of projects that a developer is engaged in.

In addition, we identified literature reviews that mapped SECO (Manikas and Hansen, 2013) and MSECO studies (Fontão et al., 2015). However, we did not find any study that investigate the reasons why developers of mobile applications join a certain ecosystem and decide to continue contributing to it over time. We started by broadly investigating the MSECO literature to verify which topics are discussed, their evolution over the years and how the studies are distributed per dimension (technical, business, and social) (Campbell and Ahmed, 2010; dos Santos and Werner, 2011) and per MSECO element (Fontão et al., 2015) (see Section 2.2). In this systematic mapping literature (Steglich et al., 2019b), we also identified which authors publish on the topic as well as their collaborative networks. We also identified candidate factors that might attract developers to a certain MSECO and those which might influence them to decide to continue contributing to an MSECO. Preliminary results are reported by each set of factors related to a specific ecosystem dimension (technical (Steglich et al., 2019c), business (Steglich et al., 2020) and social (Steglich et al., 2019a)). The present article includes a full report of results and an in-depth analysis of the dataset and discussion related to current literature.

4. Method

Our research includes three studies as shown in Fig. 1. First, we conducted a systematic mapping study (SMS) to identify the factors that can influence mobile developers to participate in an MSECO. Next, we invited four experts in MSECO to review these factors and their descriptions and, if necessary, supplement the list. Finally, upon the list of identified factors, we invited 20 MSECO developers to report on their experience. We asked them to comment on each factor, indicating whether a certain factor had motivated them to join a certain MSECO and if such factor was relevant to affect their decision to continue contributing to it.

We posed four research questions to guide our research:

RQ1. What factors affect developers' decision to participate in an MSECO?

RQ2. Which factors are considered most relevant by developers regarding motivation to participate in an MSECO?

RQ3. How do the perceptions on those factors change over time based on the experience?

RQ4. What are the main differences on the motivations to participate in Android and iOS MSECO?

4.1. Systematic mapping study

We followed the guidelines proposed by Petersen et al. (2008) to conduct an SMS including a snowballing process as pointed by Wohlin (2014). This study aimed to verify the MSECO literature

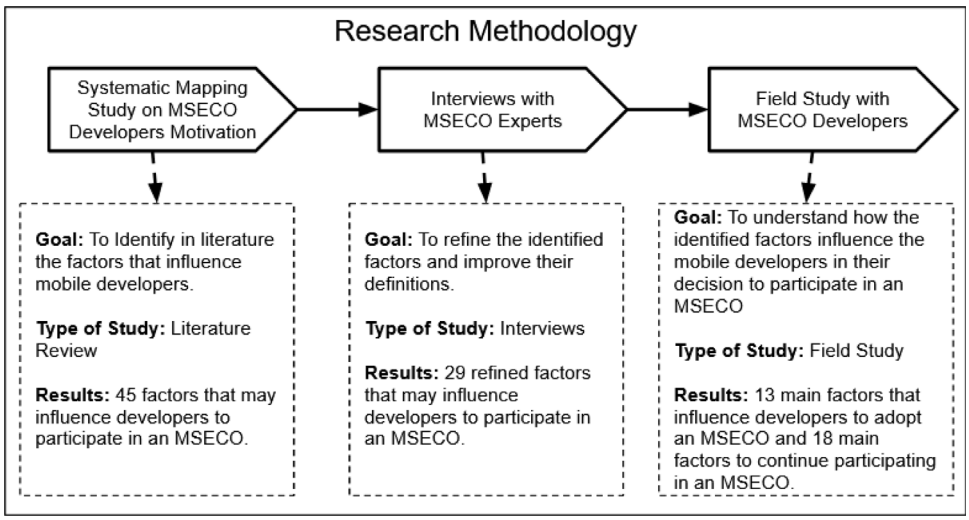

Fig. 1. Method applied to our research.

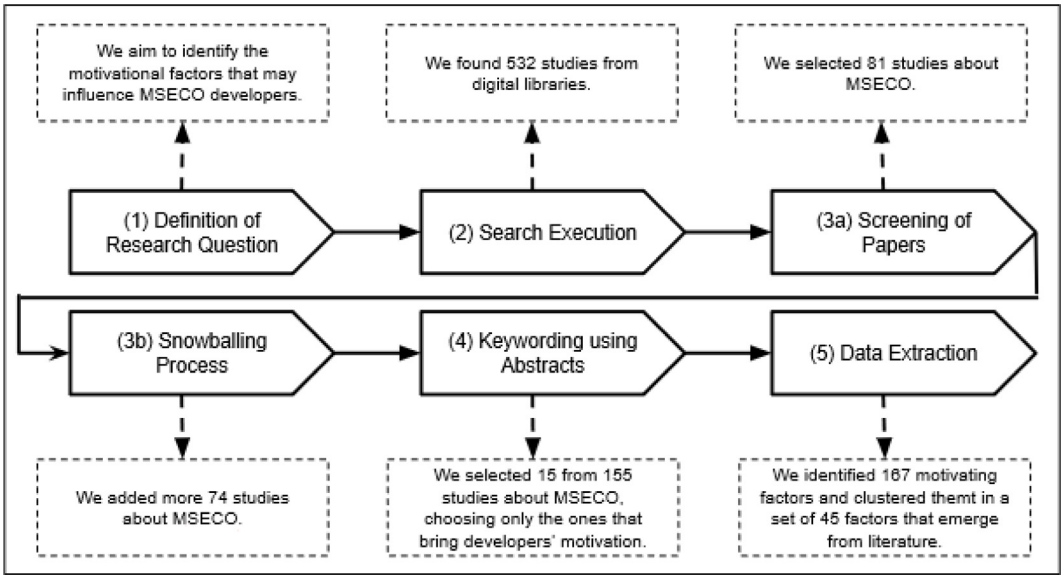

Fig. 2. Systematic mapping study process applied to our research.

and identify factors that motivate developers. Fig. 2 illustrates the SMS process and each step is described next.

Step 1. Definition of Research Question

We defined the following research questions in this SMS:
(SMS-RQ1) Which studies in the MSECO literature report on any developers' motivation factor?
(SMS-RQ2) Which are these developers' motivation factors?

Step 2. Search Execution

This step includes selecting the databases and conducting the search (Petersen et al., 2008). We selected the databases as recommended by Kitchenham and Charters (2007), namely: ACM Digital Library, IEEExplore Digital Libray, SCOPUS, Science Direct, Springer Database, and Wiley Interscience. The search execution retrieved 532 studies. The search string is defined as follows:

> Title-Abstract-Keyword{MSECO OR [Mobile AND (Software Ecosystem OR SECO)] OR [smartphone AND (Software Ecosystem OR SECO)]}

Table 1
Inclusion criteria.

ID	Inclusion criteria
(I1)	Study reports on any aspect of an MSECO in title, keywords or abstract
(I2)	Study reports on MSECO developers' motivation

Step 3a. Screening of Papers

We screened through title, keywords and abstract of each study and then applied the inclusion and exclusion criteria. The inclusion criteria are reported in Table 1, while the exclusion criteria are listed in Table 2. After applying such criteria, we selected 81 out of 532 studies.

Step 3b. Snowballing Process

We applied snowballing as proposed by Wohlin (2014), which is comprised of two processes – forward snowballing and backward snowballing –, as explained next:

Table 2
Exclusion criteria.

ID	Exclusion criteria
(E1)	Study is duplicated
(E2)	Study published before 2007[a]
(E3)	Study is a conference abstract
(E4)	Study written in other languages than English or Portuguese

[a]Manikas and Hansen (2013) report that SECO studies have started in 2007. Given that MSECO is a category of SECO, we defined this search starting date.

Table 3
Selected studies.

ID	Study	Reference
S1	Fontão, Dias-Neto and Santos (2017)	Fontão et al. (2017)
S2	Sadi, Dai and Yu (2015)	Sadi et al. (2015)
S3	Dobrica and Pietraru (2017)	Dobrica and Pietraru (2017)
S4	Ryu, Kim and Kim (2014)	Ryu et al. (2014)
S5	Kim, Kim and Lee (2016)	Kim et al. (2016)
S6	Goldbach, Benlian and Buxmann (2017)	Goldbach et al. (2017)
S7	Miranda et al. (2014)	Miranda et al. (2014)
S8	Koch and Kerschbaum (2014)	Koch and Kerschbaum (2014)
S9	Rieger and Majchrzak (2016)	Rieger and Majchrzak (2016)
S10	Koch and Guceri-Ucar (2017)	Koch and Guceri-Ucar (2017)
S11	Deniz and Kehoe (2013)	Deniz and Kehoe (2013)
S12	Choi, Nam and Kim (2018)	Choi et al. (2018)
S13	Ferreira (2016)	Ferreira (2016)
S14	Choi, Nam and Kim (2017)	Choi et al. (2017)
S15	Goldbach and Benlian (2015)	Goldbach and Benlian (2015)

- Forward Snowballing: Given the initial set of 81 selected studies, we used Google Scholar[1] to identify new studies which have cited the studies of the initial set. Next, we applied the inclusion and exclusion criteria. We repeated this process until no new unclassified studies are retrieved. We have identified 28 new studies using forward snowballing (26 from the first selection cycle and 2 from the second one);
- Backward Snowballing: Given the initial set of 81 selected studies, we used their references to identify new potential studies to this SMS. Next, we applied the inclusion and exclusion criteria. We repeated this process until no new unclassified studies are retrieved. We have identified 46 new studies using backward snowballing (42 from the first selection cycle and 4 from the second one).

At the end, we have identified 74 (28 + 46) new studies. We added these studies to the initial set of 81 studies, resulting in 155 selected studies about MSECO.

Step 4. Keywording using Abstracts

We read the abstract and looked for keywords and concepts that meet the SMS goal (identification of motivation factors). We selected 15 out of 155 studies as indicated in Table 3 in order to answer SMS-RQ1.

The selection was conducted by three researchers. Each one received a set of equally and randomly assigned-to-review studies. Later, the most senior researcher revisited the categorization of the other two. The senior researcher, with almost 20 years of experience in qualitative studies and over five years of experience in MSECO research, double checked the results by classifying herself about one-third of the dataset. Since the agreement level was over 85%, she decided to inspect the remaining studies in Table 3 to make sure they have also been selected correctly. Any discrepancy was discussed upon the mediation of an extra senior researcher with the same experience of hers.

[1] Google Scholar - https://scholar.google.com.br/.

Table 4
Example of the cluster technique to generate F15 — To have access to hardware with an acceptable performance.

ID	Candidate factor	Study
1	Hardware performance	Koch and Kerschbaum (2014)
...		
2	SDK quality	Sadi et al. (2015)
...		
2	SDK quality	Ryu et al. (2014)
...		
1	Hardware performance	Dobrica and Pietraru (2017)
...		

Step 5. Data Extraction

We performed the extraction of factors from 15 selected studies by reading their full texts. We extracted 167 candidate factors, including duplicated or similar factors. Thus, we clustered these factors using the Card Sorting analysis method presented by Spencer (2009). We adopt the Open Card Sorting approach to cluster 167 factors by similarities, i.e., two or more factors that express the same content or a very similar content must be merged into a single factor. Table 4 illustrates an excerpt of the clustering process for the identified factor F15 — To have access to hardware with an acceptable performance. Therefore, 167 candidate factors were clustered into 45 factors. These 45 factors identified from literature (see Table 5) answer SMS-RQ2.

4.2. Interviews with MSECO experts

After conducting an SMS, we invited experts to evaluate the 45 factors and their descriptions. Flick (2014) recommends this strategy to get insights from applying another method to revisit an object of study. We discussed the factors with four experts in MSECO, i.e., professionals who work with mobile software development. We present details on this study next.

4.2.1. Characterization of experts

The MSECO experts have the following profiles:

Expert 1 (E1): An assistant professor and researcher (5 years of experience), he has worked for 10 years in the software industry. Out of these 10 years, he has worked 2 years as an application developer and 4 years as a developer evangelist in an MSECO. During this time, he contributed to Android, Windows Phone, and Symbian.

Expert 2 (E2): An instructor with 3 years of experience in mobile software development to iOS.

Expert 3 (E3): An associate professor with over 30 years of experience in the IT area. Former software developer, he currently manages the R&D partnership between the university where he works and Microsoft, which includes developing courses to train students on Microsoft technologies and to develop proof-of-concepts projects with industry partners. He has been teaching mobile software development for 9 years. He has contributed to Android, Windows Phone, and iOS.

Expert 4 (E4): A senior mobile software development instructor with 12 years of experience. He has contributed to Android, Windows Phone, iOS, and BlackBerry.

4.2.2. Procedure

We asked the experts to answer the following questions:

1. Do you agree with the definition of each factor? Otherwise, please report the factor ID and explain why you disagree.
2. Would you remove some factor from the list? Which one? If so, could you justify your answer?

Table 5
Initial list of factors.
Source: 1st study - SMS.

ID	Factor	Citation
_F1	To have fun when developing an application	Koch and Kerschbaum (2014), Sadi et al. (2015), Koch and Guceri-Ucar (2017) and Goldbach and Benlian (2015)
_F2	To compete aiming to improve developer skills and intellect	Koch and Kerschbaum (2014), Sadi et al. (2015), Dobrica and Pietraru (2017), Koch and Guceri-Ucar (2017) and Choi et al. (2018, 2017)
_F3	To learn and improve skills	Koch and Kerschbaum (2014), Fontão et al. (2017), Sadi et al. (2015), Dobrica and Pietraru (2017), Kim et al. (2016), Miranda et al. (2014), Rieger and Majchrzak (2016), Koch and Guceri-Ucar (2017), Deniz and Kehoe (2013), Ferreira (2016) and Goldbach and Benlian (2015)
_F4	To contribute with new projects	Koch and Kerschbaum (2014)
_F5	To become recognized by the community	Koch and Kerschbaum (2014), Fontão et al. (2017), Sadi et al. (2015), Koch and Guceri-Ucar (2017) and Deniz and Kehoe (2013)
_F6	To feel satisfied about the relationship with the MSECO	Koch and Kerschbaum (2014), Koch and Guceri-Ucar (2017) and Deniz and Kehoe (2013)
_F7	To earn money through compensation or sales	Koch and Kerschbaum (2014), Fontão et al. (2017), Sadi et al. (2015), Rieger and Majchrzak (2016), Koch and Guceri-Ucar (2017) and Deniz and Kehoe (2013)
_F8	To pay the developer because is less expensive than adapt an existent solution	Koch and Kerschbaum (2014) and Dobrica and Pietraru (2017)
_F9	To possess the desired technical resources	Koch and Kerschbaum (2014), Ryu et al. (2014), Sadi et al. (2015), Dobrica and Pietraru (2017), Kim et al. (2016), Miranda et al. (2014), Rieger and Majchrzak (2016), Deniz and Kehoe (2013) and Ferreira (2016)
_F10	To get a great installed base over applications	Koch and Kerschbaum (2014) and Sadi et al. (2015)
_F11	To configure the operating system	Koch and Kerschbaum (2014) and Dobrica and Pietraru (2017)
_F12	To face no barriers to access the market and sell the app	Koch and Kerschbaum (2014), Sadi et al. (2015) and Koch and Guceri-Ucar (2017)
_F13	To adapt the developer application to several kinds of devices	Koch and Kerschbaum (2014), Dobrica and Pietraru (2017), Rieger and Majchrzak (2016) and Deniz and Kehoe (2013)
_F14	To have penetration in the applications	Koch and Kerschbaum (2014) and Deniz and Kehoe (2013)
_F15	To have access to hardware with an acceptable performance	Koch and Kerschbaum (2014), Dobrica and Pietraru (2017) and Rieger and Majchrzak (2016)
_F16	To update frequently the operating system	Koch and Kerschbaum (2014) and Koch and Guceri-Ucar (2017)
_F17	To be able to buy devices by a fair price	Koch and Kerschbaum (2014)
_F18	To feel satisfied about the relationship with the MSECO	Koch and Kerschbaum (2014), Ryu et al. (2014), Kim et al. (2016), Deniz and Kehoe (2013), Choi et al. (2018, 2017) and Goldbach and Benlian (2015)
_F19	To contribute to a great MSECO that has a great number of apps in the application store	Koch and Kerschbaum (2014), Sadi et al. (2015) and Koch and Guceri-Ucar (2017)
_F20	To select the channels to share the application	Koch and Kerschbaum (2014), Rieger and Majchrzak (2016) and Deniz and Kehoe (2013)
_F21	To have freedom to change the operating system	Koch and Kerschbaum (2014), Sadi et al. (2015) and Rieger and Majchrzak (2016)
_F22	To consider different user profiles	Koch and Kerschbaum (2014), Dobrica and Pietraru (2017) and Choi et al. (2018, 2017)
_F23	To have the opportunity to get a nice job	Ryu et al. (2014)
_F24	To get fair reviews from applications	Ryu et al. (2014) and Kim et al. (2016)
_F25	To believe in revenue share with MSECO	Ryu et al. (2014), Kim et al. (2016) and Deniz and Kehoe (2013)
_F26	To feel attracted by market demand	Kim et al. (2016) and Deniz and Kehoe (2013)
_F27	To exchange knowledge between developers and community	Kim et al. (2016), Rieger and Majchrzak (2016) and Goldbach and Benlian (2015)
_F28	To setup easily the platform	Kim et al. (2016)
_F29	To hardly lose money in SECO	Kim et al. (2016)
_F30	To self-manage work flow and pace	Goldbach et al. (2017) and Goldbach and Benlian (2015)
_F31	To test applications	Miranda et al. (2014), Rieger and Majchrzak (2016) and Ferreira (2016)
_F32	To observe application in the platform	Miranda et al. (2014) and Ferreira (2016)
_F33	To choose a certain MSECO based on the offered advantages	Miranda et al. (2014) and Ferreira (2016)

(*continued on next page*)

Table 5 (*continued*).

ID	Factor	Citation
_F34	To allow developers get open resources from the platform	Rieger and Majchrzak (2016) and Choi et al. (2018, 2017)
_F35	To have access to tools and guidelines to aid the design and development of the application user interface	Rieger and Majchrzak (2016)
_F36	To identify oneself with and feel committed with the community	Rieger and Majchrzak (2016) and Choi et al. (2018, 2017)
_F37	To consider different user profiles	Rieger and Majchrzak (2016)
_F38	To get support for the application entire life cycle	Rieger and Majchrzak (2016)
_F39	To get support while integrating an application	Rieger and Majchrzak (2016)
_F40	To develop applications with built-in security features provided by the platform	Rieger and Majchrzak (2016)
_F41	To allow developers get resources to make good applications appearances	Rieger and Majchrzak (2016)
_F42	To think in different kinds of people when developing	Rieger and Majchrzak (2016)
_F43	To allow applications get compatibility resources from the device	Deniz and Kehoe (2013) and Choi et al. (2018, 2017)
_F44	To enter a large and fair community of application developers	Deniz and Kehoe (2013)
_F45	To get user participation	Deniz and Kehoe (2013) and Choi et al. (2018, 2017)

Table 6
Merged factors.

Factors		Quote
F9	F34	"I feel that is very connected to F9. To open, there are resources available as license, freedom to create." (E1)
F9	F37	"It seems to me a very weak factor, most auxiliary devices are already docked in the device. This is hard to happen. Maybe F37 + F9." (E2)
F9	F39	"It can integrate F9 + F39 because alone it is not motivating." (E3)
F10	F45	"I see F35 and F41 as a common zone, meaning they are basically the same thing." (E4)
F35	F41	"It seems repetitive with F10. Maybe both should be: To get a great installed base over your applications." (E1)

Table 7
Removed factors.

Factor	Quote
F8	"Rarely developing is cheaper than buying or adapting something." (E3)
F11	"The developer is afraid to using these features, such as accessing hardware." (E2)
F13	"This factor does not seem motivating to me, but demotivating." (E3)
F16	"Frequent updates can lead to unexpected behavior and the developer needs to waste time." (E1)
F19	"Number of applications is not always attractive because the number of applications can hide the quality with which it was made." (E2)
F21	"This used to work in the past, when only making software for themselves or for internal company use." (E3)
F24	"It is important but all ecosystems currently provide it." (E3)
F31	"Developers can verify, but can hardly validate, many do not understand validation with users as part of the process." (E1)
F32	"It makes more sense for indie developers, but not for professional developers because in-store tracking is not one of their functions. (E2)
F36	"It does not seem to me like a factor, the developer relying on a platform does not motivate." (E2)
F43	"With a computer with Windows I can develop both Android and iOS, without doing anything special, here the platform is irrelevant." (E3)

3. Would you add some factor to the list? If so, could you justify your answer?
4. Would you merge any of these factors? Which of them and how?
5. Would you like to provide any further comment on this research?

Each expert was invited to a face-to-face interview to evaluate 45 factors. Each factor was presented through cards, containing their titles and definitions from the literature. Each expert was then invited to explain whether he/she agreed with the definition of each factor, would remove or add some factors (merging some of them from the list), or would like to provide any comment on the research. The interviews lasted an average of 60 min and the experts were allowed to return to previously analyzed factors and review their comments, if necessary. The interviews were later transcribed.

The analysis followed the Card Sorting approach. Five researchers involved in this study participated in this procedure, being three of them students who put experts' comments in a table and analyzed by similarity (the same approach used in the SMS to data analysis). Merges, removals or additions of factors were not based only on a single expert opinion, but when experts converged on that. This procedure was validated by two senior researchers, who assisted the students in improving the quality of the analysis.

Based on the information obtained from the experts' opinions, the following decisions were made: (1) 29 factors (F1, F2, F3, F4, F5, F6, F7, F9, F10, F12, F14, F15, F17, F18, F20, F22, F23, F25, F26, F27, F28, F29, F30, F33, F35, F38, F40, F42 and F44) were kept because the experts agreed that they could affect the developers' motivation; (2) we merged some factors as presented in Table 6; and (3) Table 7 presents the removed factors as well as the experts' quotes supporting the actions. At the end, the factors presented in Table 8 resulted from this study and ware ordered by their discovery — their definitions are presented in Appendix.

4.3. Field study with MSECO developers

After obtaining the opinions of MSECO experts, we conducted a field study to identify which factors may affect the developers to start or continue contributing to an MSECO. To do so, we performed a set of interviews based on Singer and colleagues' recommendations for field studies (Singer et al., 2008). We invited MSECO developers to share their experiences and tell us about how the list of 29 factors may affect them to participate in an ecosystem based on semi-structured interviews as proposed by Seaman (2008). We asked the developers to answer the following questions:

1. When does each factor affect you in both moments — when you started contributing to an MSECO, and/or when you continue contributing to it over time?
2. How did/does each factor influence your participation within an MSECO? Is there any factor that did/do not affect you? Could you please tell us how?

Table 8
Revised list of factors.
Source: 2nd study — interviews with MSECO experts.

ID	Factor	Citation
F1	To contribute with new projects	Koch and Kerschbaum (2014)
F2	To possess the desired technical resources	Koch and Kerschbaum (2014), Ryu et al. (2014), Sadi et al. (2015), Dobrica and Pietraru (2017), Kim et al. (2016), Miranda et al. (2014), Rieger and Majchrzak (2016), Deniz and Kehoe (2013), Choi et al. (2018), Ferreira (2016) and Choi et al. (2017)
F3	To have access to hardware with an acceptable performance	Koch and Kerschbaum (2014), Dobrica and Pietraru (2017) and Rieger and Majchrzak (2016)
F4	To setup easily the platform	Kim et al. (2016)
F5	To have access to tools and guidelines to aid the design and development of the application user interface	Rieger and Majchrzak (2016)
F6	To develop applications with built-in security features provided by the platform	Rieger and Majchrzak (2016)
F7	To consider different user profiles	Rieger and Majchrzak (2016)
F8	To earn money through compensation or sales	Koch and Kerschbaum (2014), Fontão et al. (2017), Sadi et al. (2015), Rieger and Majchrzak (2016), Koch and Guceri-Ucar (2017) and Deniz and Kehoe (2013)
F9	To get a great installed base over applications	Koch and Kerschbaum (2014), Sadi et al. (2015), Deniz and Kehoe (2013) and Choi et al. (2018, 2017)
F10	To face no barriers to access the market and sell the app	Koch and Kerschbaum (2014), Sadi et al. (2015) and Koch and Guceri-Ucar (2017)
F11	To have penetration in the applications market	Koch and Kerschbaum (2014) and Deniz and Kehoe (2013)
F12	To be able to buy devices by a fair price	Koch and Kerschbaum (2014)
F13	To select the channels to share the application	Koch and Kerschbaum (2014), Rieger and Majchrzak (2016) and Deniz and Kehoe (2013)
F14	To adapt the developer application to several kinds of devices	Koch and Kerschbaum (2014), Dobrica and Pietraru (2017) and Choi et al. (2018, 2017)
F15	To have the opportunity to get a nice job	Ryu et al. (2014)
F16	To believe in revenue share with MSECO	Ryu et al. (2014), Kim et al. (2016) and Deniz and Kehoe (2013)
F17	To feel attracted by market demand	Kim et al. (2016) and Deniz and Kehoe (2013)
F18	To hardly lose money in MSECO	Kim et al. (2016)
F19	To get support for the application entire life cycle	Rieger and Majchrzak (2016)
F20	To have fun when developing an application	Koch and Kerschbaum (2014), Sadi et al. (2015), Koch and Guceri-Ucar (2017) and Goldbach and Benlian (2015)
F21	To compete aiming to improve developer skills and intellect	Koch and Kerschbaum (2014), Sadi et al. (2015), Dobrica and Pietraru (2017), Koch and Guceri-Ucar (2017) and Choi et al. (2018, 2017)
F22	To learn and improve skills	Koch and Kerschbaum (2014), Fontão et al. (2017), Sadi et al. (2015), Dobrica and Pietraru (2017), Koch and Guceri-Ucar (2017), Kim et al. (2016), Rieger and Majchrzak (2016), Deniz and Kehoe (2013), Miranda et al. (2014), Ferreira (2016) and Goldbach and Benlian (2015)
F23	To become recognized by the community	Koch and Kerschbaum (2014), Fontão et al. (2017), Sadi et al. (2015), Koch and Guceri-Ucar (2017) and Deniz and Kehoe (2013)
F24	To identify oneself with and feel committed with the community	Koch and Kerschbaum (2014), Koch and Guceri-Ucar (2017) and Deniz and Kehoe (2013)
F25	To feel satisfied about the relationship with the MSECO	Koch and Kerschbaum (2014), Ryu et al. (2014), Kim et al. (2016), Deniz and Kehoe (2013), Choi et al. (2018, 2017) and Goldbach and Benlian (2015)
F26	To exchange knowledge between developers and community	Kim et al. (2016), Rieger and Majchrzak (2016) and Goldbach and Benlian (2015)
F27	To self-manage workflow and pace	Goldbach et al. (2017) and Goldbach and Benlian (2015)
F28	To choose a certain MSECO based on its advantages	Miranda et al. (2014) and Ferreira (2016)
F29	To enter a large and fair community of application developers	Deniz and Kehoe (2013)

3. Would you like to provide any further comment on this research?

4.3.1. Characterization of developers

We invited developers with experience in mobile software development for face-to-face interviews. They have participated in Android, iOS, or both MSECO, and their characterization is presented in Table 9. The interviewees have a varied profile, being developers to Android or iOS MSECO and also employees of small, medium or large companies. Some of them have worked on restricted or confidential projects, while others have experience in developing open source applications. Developers have also worked or are currently working as programmers, mobile development course instructors, or mobile application project managers.

4.3.2. Procedure

Before starting the interviews, we conducted a pilot to validate the interview questions and verify if any changes should be made in the planned procedure. The participants were selected by convenience. This interview was conducted with a developer who

Table 9
Characterization of MSECO developers.

ID	Company size	Experience time	MSECO	
			Android	iOS
D1	Small	5 years	✓	✓
D2	Large	7 years	✓	✓
D3	Medium	7 years	✓	
D4	Small	9 years	✓	
D5	Small	3 years	✓	✓
D6	Small	4 years	✓	
D7	Medium	6 years	✓	✓
D8	Medium	3 years	✓	✓
D9	Medium	3 years		✓
D10	Medium	1 year	✓	✓
D11	Medium	4 years		✓
D12	Large	3 years	✓	✓
D13	Small	1 year	✓	
D14	Large	2 years	✓	✓
D15	Small	4 years		✓
D16	Large	5 years	✓	✓
D17	Small	2 years		✓
D18	Small	2 years		✓
D19	Small	2 years	✓	
D20	Medium	2 years	✓	

has worked for four years with mobile software development in Android and iOS. It took approximately one hour, becoming much more feasible. We identified the need for understanding the importance of the factors according to the experience of the developer. We also began to ask how the developer's perception on the factors have changed over time. Next, 20 developers were invited by convenience — they worked/works in different mobile software development companies that belong to a technological pole.

In this study, a concept adopted to establish the number of required interviews refers to "saturation". According to Creswell (1998), a saturation is reached when performing a new set of interviews does not come up with any new emerging data. It is a challenge to define how many interviews are required to conclude a field study. We exceeded the reference recommendation of Guest et al. (2006), who explain that a saturation usually could be obtained with 12 interviews, given that our group of interviewees is very homogeneous (i.e, they are all MSECO developers). Other studies published in reference journals also followed Guest and colleagues' recommendations: (1) Greiler et al. (2022), who interviewed 21 developers to understand what affects developer experience to support organizations that want to enable more productive and effective work environments; and (2) Ribeiro et al. (2022), who interviewed 15 software developers to understand better what leads to or avoids conflicts in a merge based on a list of factors.

We verified if the collected data were still insufficient throughout the interviews (i.e., a saturation was not reached). After the analysis, we observed that those 20 interviews did not present new results to some point, thus reaching saturation. We heard several opinions from MSECO developers, but there was no new categories of codes emerging after the 11th interview — in other words, from the 12th developer, opinions were considered similar to the previous ones.

In each interview, we asked an MSECO developer to read the cards containing 29 factors with their descriptions. For each card, three questions were performed as described previously, regarding the moment when each factor affects the developers, how each factor influence the developers' participate in an MSECO, and further comments on the research. The interviews lasted an average of 40 min and were recorded with the consent of the participant (and subsequently transcribed). Notes were took during each interview as a way to highlight the main points discussed with the participant and served as supporting material in the analysis.

The analysis of the interviews was also performed according to Spencer's Card Sorting process (Spencer, 2009), which is similar to a Grounded Theory coding process, but in a more visual and simplified way. Card Sorting was used in the search for merging similar answers from the interviewees through codes and thus to understand how each factor was realized by the MSECO developers.

5. Results

In this section, we answer the four research questions.

5.1. Factors that affect developers' decision to participate in an MSECO (RQ1)

The developers were interviewed to explain how they realize each factor (a summary is presented in Table 10), considering just their own experience, not representing their organizations' opinions, and how these factors influence their routine as developers (D*x*, where *x* is a developer ID).

(F1) To contribute with new projects

Several developers associate this factor with innovation, i.e., the creation of innovative applications – *"I had a lot of curiosity and a lot of ideas, and I always wanted to do new things that the market had not yet"* (D11). This brings new horizons, making some new market opportunities emerge, and a developer can stand out – *"We were able to identify new demands, or gaps, and new needs that could be solved through mobile applications"* (D4). Contribution with something new helps to get a developer out of the comfort zone so that he/she does not calm down – *"Something new is interesting and leads to an idea of exploring reality. It is more of a feeling of adventure, the challenge is very cool"* (D18).

(F2) To possess the desired technical resources

When a developer starts contributing to an MSECO, this novice developer usually does not observe the technical resources, because he/she is not aware of them and do not know how to evaluate them at that stage – *"At first I had no idea of this sort of thing. I did not know about tools, I did not know about libraries and these kinds of support"* (D16). The developers point out that when some technical resource is lacking, it can significantly impact production, causing a developer to think strategies on how to handle problems – *"You need this, if you do not know the tools, you can do without them, but they always help, being effective"* (D17).

However, older developers recognize that technical features have improved considerably in recent years – *"The solution and documentation of the platform that I develop are in continuous update and the documentation is always updated. They are always adding new solutions to the problems that we identify"* (D4). Frequently, technical resources are used as decision criteria by developers, because they become discouraged when they miss an important resource – *"The quality of your work depends a lot on that, and having access to application building tools is essential for you to be able to write your code faster, more efficiently"* (D10).

(F3) To have access to hardware with an acceptable performance

Currently, there is a wide variety of devices, which has been a potential challenge for developers. When developing applications, a software must be fit to all manufacturers and brands – *"There are many devices, mainly for Android, and you have a very large variation of hardware"* (D2). Because of such variation, developers have presented more concerns about application

Table 10
Factors to start and continue contributing to an MSECO.
Source: 3rd study — interviews with MSECO developers.

ID	Factor	To start	To continue	Variation
F1	To contribute with new projects	16	17	1
F2	To possess the desired technical resources	14	17	3
F3	To have access to hardware with an acceptable performance	8	18	10
F4	To setup easily the platform	12	14	2
F5	To have access to tools and guidelines to aid the design and development of the application user interface	14	17	3
F6	To develop applications with built-in security features provided by the platform	15	18	3
F7	To consider different user profiles	4	10	6
F8	To earn money through compensation or sales	11	15	4
F9	To get a great installed base over applications	12	12	0
F10	To face no barriers to access the market and sell the app	14	15	1
F11	To have penetration in the applications market	12	13	1
F12	To be able to buy devices by a fair price	12	12	0
F13	To select the channels to share the application	14	14	0
F14	To adapt the developer application to several kinds of devices	10	12	2
F15	To have the opportunity to get a nice job	13	19	6
F16	To believe in revenue share with MSECO	9	12	3
F17	To feel attracted by market demand	15	17	2
F18	To hardly lose money in MSECO	10	8	−2
F19	To get support for the application entire life cycle	10	20	10
F20	To have fun when developing an application	14	17	3
F21	To compete aiming to improve developer skills and intellect	10	16	6
F22	To learn and improve skills	16	17	1
F23	To become recognized by the community	3	11	8
F24	To identify oneself with and feel committed with the community	9	14	5
F25	To feel satisfied about the relationship with the MSECO	13	15	2
F26	To exchange knowledge between developers and community	14	20	6
F27	To self-manage workflow and pace	12	17	5
F28	To choose a certain MSECO based on its advantages	13	13	0
F29	To enter a large and fair community of application developers	12	18	6

performance as a frequent challenge – *"I focus a lot on performance, so Android is the operating system that has more users in the world"* (D19).

Despite the negative effects, some developers appreciate the market opportunities that arise as a result of the variation of devices and produce more versatile applications – *"The more devices that run your application, the more people will be able to use it, and I have always taken into account the client being able to run the application on the hardware it has. So, I do not have to buy hardware just for my application"* (D3).

(F4) To setup easily the platform

Developers often appreciate when the platform is easily configurable since it saves time – *"The easier to configure the platform from the beginning when you are developing these applications, the better, because you do not know anything, everything is new. If the platform is easy to configure, it is feasible to go straight to the code and learn what really matters"* (D3). However, once the developer goes through such problems, he/she learns how to deal with them, configuring the platform in a more practical way – *"In practice it does not happen, as I have a certain degree of experience, it is not something that will directly influence my work"* (D8).

(F5) To have access to tools and guidelines to aid the design and development of the application user interface

Initially, novice developers often keep their focus on functionality of applications – *"Nowadays, we worry more about it. This was not our concern in the old days - the concern was functionality. There were only a few applications; it was not much for mobile; today everything turns into an application"* (D7). An MSECO currently offers several resources so that pre-built tools for creating interfaces help developers to standardize the application without wasting much time on that – *"Even being in agreement with everyone (or if not), you have to work harder because you have to think more about how you will make this interface"* (D4).

Regarding the monetary issue, developers want to make their applications as pleasant as possible to attract as many users as possible, since they are potential customers – *"We develop applications to the client, thinking about him/her; it has to be a pleasant experience. It is no useful if our work does not make sense to the customer, or if it is difficult to use"* (D16). In addition, some developers believe that the appearance must be a differential to attract developers even with interface standards – *"This has become a way to differentiate your applications from others, by doing different things and perhaps implementing something new. However, taking into consideration usability issues helps you do not invent something completely crazy"* (D1).

(F6) To develop applications with built-in security features provided by the platform

Nowadays, developers recognize and usually treat security as a concern of great importance – *"Security is an essential thing. However, please simplify the data you are dealing with as you can always do something"* (D18). This happens because developers are very worried about sensitive user data, which may be shown to undesirable people – *"Sometimes, you have to protect the customer data: you have to show the customer that you have a secure application, that he/she can use it without any problem, how his/her data is stolen, things like that"* (D5). In fact, a developer do not want to get this responsibility but rather the support of the platform to deal with such issues, which can incur in legal implications – *"It would be the case of login and password and I never took time to have, for example, an encrypted transmission of such data or things like that"* (D3).

(F7) To consider different user profiles

Accessibility and support for different user profiles have not been considered since several developers have not carried out projects whose scope is to reach a large number and variety of people. So, they have not thought on such a perspective – *"Different profiles are not a big concern because today we focus a lot on the user that will run the software, so we have the profile of him/her there"* (D7).

In this context, it depends on the focus that a developer wants for his/her applications. Sometimes, some developers may want

as many customers as possible for their applications and thus he/she demonstrates a concern with several user profiles – *"For the sake of having worked on a large project, I realized how many people you are excluding when you do not think about usability or that specific function that not everyone knows how to do"* (D11). However, some projects are stipulated with a restricted audience, affecting how an application will be distributed – *"I usually worked with apps for a specific audience, so I did not offer solutions to many different user profiles"* (D6).

(F8) To earn money through compensation or sales

When a developer wonders if he/she would continue contributing to an MSECO, the financial benefits is often motivating him/her to stay – *"Many times, this is the reason why I did not give up"* (D3). In an MSECO, there are several forms of monetization that a developer can use, and he/she can earn money by producing applications for companies or simply making them available in the store – *"It has always been important how free a developer wants to be to make money. Whether he/she wants to make an application and make money selling or making a subscription system, that is great, and if he/she wants to sell his/her workforce to a company, that is fine as well"* (D9).

However, the salary paid to developers of mobile software frequently ends up being something that attracts them to participate in an MSECO, because it is an emerging market and many companies invest in mobile solutions – *"As for the monetization (-)the salary, in this case, it is important to get money according to what you are developing to the platform"* (D5). Monetization also gains importance because the profit of an application can maintain its project and other new projects that its developer owns so that he/she can invest it – *"To support any application, one need to give you money. If you make a product that does not have a financial bias, it has to have at least something that will give you a long-term gain. So, if you are not making money now, at least you will have to make money in the future, whether you use it as a gateway to another project, or not"* (D10).

(F9) To get a great installed base over applications

Developers point out that the important thing is not necessarily the number of users, but the number of clients, i.e., users who invest in an MSECO – *"Based on the audience that uses the platform, you are more likely to be successful or not. However, depending on your application, you may even be small, but reaching a large portion of that audience"* (D6). On the other hand, there are those who believe that the more users you reach, the better you are, given the potential customers – *"Whenever I started working, the large user base was important, you know, because the more users you have, the more people your application will reach and the more likely they will invest on that"* (D3). In addition, developers mention that applications should attract an installed base, because this helps the attraction of new customers – *"I think developers 'sin' when they want to offer everything in the application based on a single delivery, taking a lot of time-to-market and not creating a user base"* (D5).

(F10) To face no barriers to access the market and sell the app

High barriers can demotivate a developer to participate in an MSECO – *"Reducing barriers is very important because it encourages more developers to enter the mobile market, making the platform less bureaucratic and abstract to simply buy, download and start using, learning, and getting started in the store"* (D9). For the development of applications, developers do not consider that there are major barriers to production, because there are usually no expansive costs beyond the initial ones – *"We always have other ways to do so. Even if you have some barrier, you can explore other ways to do it, like using open-source tools"* (D8).

According to some developers, market barriers depends on the MSECO platform they contribute to – *"In fact, the iOS market does not have low barriers: you have to have an iPhone or an iPad, and to be able to build a Mac machine"* (D2). However, some barriers may be positive for the application market to ensure the quality of applications set by an MSECO – *"I noticed that such strategy increased the quality of the applications that are in the store over time"* (D11).

(F11) To have penetration in the applications market

Market penetration is not of a huge importance, since some developers are tied to closed projects, so the target audience is quite restricted – *"I did not experience this, because we developed for a particular client"* (D7). However, to make applications available on the market, some developers usually focus on large groups of users – *"the amount of customers you need for your application is important to make your name and generate an income as well"* (D15). Moreover, to reach a large set of users, some developers usually create applications to both MSECO market leaders (Android and iOS) – *"There are two directions: you will make applications for either iOS or Android"* (D8).

(F12) To be able to buy devices by a fair price

The acquisition of devices by the development teams is considered if such devices facilitate application testing – *"I have more than one device that is for testing. If the hardware is very expensive, I cannot get this hardware"* (D4). If the price is affordable, more users in the market can own a device – *"With cheaper devices, you have a greater base of users and end up making more customers"* (D17).

(F13) To select the channels to share the application

Nowadays, developers have several ways to distribute applications, besides the official stores – *"Being able to choose where you will distribute applications is crucial if you want to develop mobile software. You end up focusing on the Apple Store and Google Play, but you can go further, with other distribution methods"* (D1). There are also developers who do not use multiple stores since an official store ends up being enough and developers keep their focus on it – *"I always liked when information to is concentrated in one place, especially in the sale of a product"* (D9).

In some cases, there are developers who admit that they are not responsible for application distribution – *"We were not responsible for the app distribution"* (D2). However, distribution channels can offer several features, e.g., developers usually like resources such as statistics and the possibility of distributing applications in different countries – *"You have to see beyond your application: you have a demand and it is very different, for example, if you release it in Brazil or in China"* (D12).

(F14) To adapt the developer application to several kinds of devices

Usually, when starting the production of an application, developers often know or stipulate a target audience so that they think about the types of devices and their users – *"You have an audience that will use certain devices. So you have to develop apps thinking about such devices"* (D2). However, sometimes developers create applications that aim to reach as many users as possible, thus reaching a large network of potential customers – *"As a developer, I want my application to reach as many users as possible"* (D4) and *"You will surely have a greater amount of customers and you will probably have more profit"* (D5).

(F15) To have the opportunity to get a nice job

The market for mobile technologies has shown a considerable evolution and developers are attracted to the diverse job opportunities that participating in an MSECO can bring, as it fosters skills to deal with a particular development platform – *"Relationship of supply and demand is important to me as a developer, because this is usually what makes my salary increase. The more opportunities I have, the higher the demand, the better the*

supply, and the more willing to pay for the remaining supply..." (D10).

Moreover, developers look for some ways to differentiate their applications, or even the opportunities to create applications that meet new demands – *"As the Android market is very large, you have quite a chance that your application will turn out to be a fever, or you have a great chance of selling it to a large number of users, given the high number of devices over the world"* (D3).

(F16) To believe in revenue share with MSECO

Nowadays, some developers are not responsible for interactions with an MSECO, not being the ones who make the applications available in the store – *"The recipes are not frequently attractive to developers. Sometimes, it is more focused on project owners"* (D3). When a developer needs to distribute his/her applications, a good relationship with a MSECO he/she contributes to increases its credibility, thus attracting more developers – *"You can keep that developer working on this MSECO and this MSECO will have greater credibility"* (D5). Moreover, developers who distribute their applications say that participating in an MSECO should include fair and clear rules, not causing losses – *"Certainly, the rules of sharing profits have always been clear, and I think they have always been beneficial to developers"* (D1).

(F17) To feel attracted by market demand

A developer needs to ensure financial sustainability and usually thinks about ways of monetizing applications, especially when they offer some relevant service to users – *"If you do not have users paying for the service, a developer will probably not be able to support himself/herself in the market"* (D3). Therefore, monetization opportunities increase according to user consumption – *"You will have a customer base, these customers will use your product and you will monetize it"* (D5). Application consumption means that developers who have had the best applications are those who care about meeting the demands of users, because they are potential customers – *"If you have a service that is well-done and that solves your problems, nothing is fairer than charging and supporting users with such service"* (D9).

(F18) To hardly lose money in MSECO

Initially, the chances of monetary losses are higher at the beginning and this discouraged some developers – *"Currently, there are few chances, but at the beginning, the damage was very great, if I decided to stop developing"* (D7). Nowadays, developers still do not want to take risks of major losses, which has become easier to deal with – *"This is like risk management: a developer has to understand that whatever he/she takes from the paper, it can be risky. So, he/she has to check the context and the chances to work out, or to go wrong"* (D19). However, in the current context, there are few chances of major damage to a developer (rare) – *"In practice, ignoring the cost of development (past) and keeping an application in a store like Google Play will rarely bring you any loss"* (D1).

(F19) To get support for the application entire life cycle

Developers are initially unaware of features supporting the life cycle of their applications, so they often do not use them – *"I think I had less knowledge on how mobile development was done and platforms were managed. I did not have that notion, so now I see that it is very important to be aware of that"* (D1). Nevertheless, after a certain time, when a developer learns to make better use of the platform capabilities, he/she feels the need to support the life cycle of his/her applications – *"I need support for publishing my application and I also need tools or features to help monitor this application as well as to identify failures, improvements, and opportunities. I also need statistics about my application, so I can see how it works"* (D4).

Therefore, life cycle support is considered important to developers, because such support helps developers improve or maintain their applications towards their optimization – *"This will define the life of the project and how much this project will yield. Basically, our job will be guaranteed for a good time"* (D10).

(F20) To have fun when developing an application

Having fun is something personal. Some developers consider that fun is a way to increase their engagement with their projects, enhancing their involvement – *"You have to end up getting involved and engaging within the project - and end up having fun too"* (D2). Fun is considered vital and developers claim that they cannot work anymore without feeling fun when participating in a project – *"This is the reason I started to develop and by which I 'embrace' some projects which I will not gain anything"* (D11). In addition, some developers say that they feel more fun nowadays after getting more experience – *"I like programming and I end up having fun. Then I ended up falling on some project that I did not believe in so much and I lost a little enthusiasm"* (D18).

On the other hand, some developers do not like the combination of fun and work, because they believe that it is not always about fun and a developer should act professionally – *"I usually say that work is work so it can be bad and it can be good. Maybe I will be comfortable with my work if I feel comfortable doing my job"* (D8).

(F21) To compete aiming to improve developer skills and intellect

The competition has two possibilities. Firstly, a developer may incur in a competition that will take him/her out of the comfort zone and improve himself/herself as a professional – *"If we do not have this healthy competitiveness, you do not evolve a lot. You end up stagnating"* (D19). Secondly, competition can become harmful to developers and generate rivalries, producing aversion – *"Competition can ruin relationships as it can lead to applications that were made very fast to deliver quickly because a developer wanted to go faster than the other"* (D5).

(F22) To learn and improve skills

Naturally, getting skills is seen positively by developers, as they are constantly improving themselves to remain on the market – *"At first, I did not understand the potential that existed in programming. It was something I liked, and I thought: let us explore. When I realized that I liked to develop software, I started studying a new subject every day, because I feel good doing so"* (D16). However, when a developer takes a long time to master a technology, he/she can become demotivated, sometimes wanting to leave an MSECO – *"I have been worried about taking a lot of time learning some new tool, because you always want to learn quickly, but that is not often. Sometimes, it will take a long time to learn something, and you can lose motivation"* (D3).

(F23) To become recognized by the community

A developer starts his/her participation in an MSECO when he/she usually does not know the ecosystem community, so he/she does not understand its importance – *"I think that when I started to get interested in the area, I did not know much about the community"* (D1). Nowadays, developers realize that staying in the spotlight can bring employment opportunities closer. This motivates developers to be active in online or local communities – *"Someone who helps the community a lot is certainly prone to be invited for interviews and to get a job easier"* (D5).

On the other hand, many developers do not want to be known in their communities, desiring only little recognition for their contributions – *"I never had this thing. I do not say it is an ego thing, but something that never called my attention. It was never a need to be seen and recognized or things like that"* (D10). In other words, for many developers, the focus is not to become known but to disseminate knowledge, especially in their organizations – *"Nowadays, the fact that you write a good code and that you can*

apply your techniques and good practices of development within the company takes great pride" (D8).

(F24) To identify oneself with and feel committed with the community

When starting contributing to an MSECO, many developers did not care about commitment because they did not know the community very well. As such, only after a certain period of time, they felt the importance of this factor – *"You feel committed to contribute too and to give back a little of what you had for free many times. You do not pay to have that knowledge so you have an obligation to give something back to the community"* (D9).

However, considering business reasons, some developers end up having limited participation in the community due to contracts with companies, thus restricting what information they share – *"We cannot be sharing much information for confidentiality reasons, so the level of interaction was not high with the community"* (D2). A considerable contribution is that developers often seek information in communities – *"At first, I sought a lot of help in the development community. Today, I feel that I can repay it (all the help people gave to me)"* (D16).

(F25) To feel satisfied about the relationship with the MSECO

Some developers do not care so much about satisfaction since the current MSECO (Android and iOS) are very similar – *"As soon as you enter one ecosystem (Android or iOS), you realize that the existing MSECO are very similar"* (D5). Nevertheless, other developers explain that a good relationship with the ecosystems they contribute to improves their productivity – *"As you continue contributing to the ecosystem, the more you certify your applications, the harder it will be to leave the ecosystem"* (D4). However, some developers argue strongly about iOS against to Android – *"I think iOS and its native applications are very well developed and serve as a motivation to make applications"* (D16).

(F26) To exchange knowledge between developers and community

Developers realize a great number of advantages in fostering the knowledge exchange – *"The community is very active in this ecosystem. It is important: you see the staff participating, creating training, posting solutions forums etc."* (D4). Initially, developers often use only the community knowledge and sometimes do not know where to search the correct information – *"At first, you have a feeling of not contributing so much. It is not fair, because you have nothing to offer"* (D9). Moreover, some companies do not allow developers to openly share information, which means that some of them do not actively participate in the community – *"The exchange of knowledge between developers is done internally, or based on consulting information"* (D2).

(F27) To self-manage workflow and pace

Given the lack of knowledge to share when joining the ecosystem, developers may enjoy working with someone who brings the pace to the team and align the expectations with the customer – *"At first, a developer is not too worried about self-management or anything else, but later he/she can face difficulties and begin to realize the notion of organization"* (D9). When the ecosystem control structure is 'light', a developer does not believe that someone who helps him/her with their journey goes bad, which is positive for the goals of a project – *"Where I worked, I really felt that I had a satisfactory development. However, there is a time when you get stagnant and I have been losing interest sometimes on the subject. I believe a more formal issue can create an interest"* (D5). Nevertheless, after a certain time, a developer can feel confident to manage his/her routine and desire freedom, thus avoiding authoritarian people – *"I think a developer needs freedom to be able to manage his/her way of development. Of course, he/she has tasks to be addressed, but he/she has full capacity (or at least should have) to know when he/she should do a certain thing"* (D6).

(F28) To choose a certain MSECO based on its advantages

When choosing an MSECO, a developer usually analyzes the impact of such ecosystem on his/her development routine – *"Depending on the ecosystem I am contributing to, it can slow down my development time, or at least improve the way I develop"* (D6). As such, preferences emerge as some iOS developers pointed out the reason why they chose such MSECO - because it is 'nice' to use – *"iOS offers lots of abstractions for a developer, and that makes things that are very complex in other ecosystems very simple in the Apple platform as it does not have to be complicated"* (D9). Similarly, some Android developers point out the benefits of this MSECO, such as freedom and large community – *"I realized a lot of advantage in working with Android, having a large community and several market niches. A developer is well paid in this area"* (D3). Finally, a developer should create applications for both MSECO, aiming to reach a larger audience – *"When you develop for mobile platforms today, you have to develop for both Android and iOS, because otherwise you will lose half the market"* (D10).

(F29) To choose a certain MSECO based on its advantages

MSECO sustainability tends to be a challenge, because a large community seems to be a guarantee that an MSECO will survive over time – *"Community size helps development. Sometimes, it increases the credibility of that ecosystem, since you know that it is being supported currently by more users and developers, and probably it will not die anytime soon"* (D5). With a large community, a developer easily finds the information he/she needs during his/her activities – *"The larger the developers' community an MSECO has, the more content can be shared, so your work will eventually get easier when you find a problem and try to solve it"* (D8). Moreover, developers with more experience often face difficulties in finding information, even in an MSECO with a large community, since this cannot be a trivial task – *"As I am doing more complex things, I am going deeper into the code and I am facing problems that I usually do not find the solution so quickly"* (D18).

Finally, a large community ends up bringing several employment opportunities, since developers are often where users require their services – *"Size is good if you still have room in the market. At least in iOS and Android MSECO, I know that there is a plenty of room in the market"* (D15).

5.2. Most relevant factors on the motivation to participate in an MSECO (RQ2)

To start participating in an MSECO (adoption). Initially, a developer knows little about mobile technologies, which can raise their concerns and hinder their choices. Based on the results of this study, the best scored factors to start participating in an MSECO, that were pointed out by more than 15 developers, are presented in Table 11. Less than two-thirds of the interviewees considered the other factors as 'important' (some declared that they were not aware of some factors when they started participating in an MSECO).

To continue participating in an MSECO (stay). As a developer goes deeper into the mobile technologies, he/she realizes the need for more than he/she was looking for when starting in an MSECO, highlighting other factors. Based on the results of this study, the best scored factors to continue participating in an MSECO, that were pointed out by more than 15 developers, are presented in Table 12.

Table 11
Most relevant factors to start participating in an MSECO.

ID	Factor	Count	Developers
F1	To contribute with new projects	16	(D1–D7, D9–D11, D14, D16–D20)
F17	To feel attracted by market demand	16	(D1–D5, D7–D10, D12, D15–D20)
F22	To learn and improve skills	16	(D1–D3, D5, D8–D15, D17–D20)
F6	To develop applications with built-in security features provided by the platform	15	(D1–D6, D8–D10, D12–D14, D18–D20)

Table 12
Most relevant factors to continue participating in an MSECO.

ID	Factor	Count	Developers
F19	To get support for the application entire life cycle	20	(D1–D20)
F26	To exchange knowledge between developers and community	20	(D1–D20)
F15	To have the opportunity to get a nice job	19	(D1–D11, D13–D20)
F3	To have access to hardware with an acceptable performance	18	(D1–D11, D13–D14 D16–D20)
F6	To develop applications with built-in security features provided by the platform	18	(D1–D14, D17–D20)
F29	To enter a large and fair community of application developers	18	(D1, D3–D5, D7–D20)
F1	To contribute with new projects	17	(D1, D3–D4, D6–D11, D13–D20)
F2	To possess the desired technical resources	17	(D1–D11, D13, D16–D20)
F5	To have access to tools and guidelines to aid the design and development of the application user interface	17	(D2–D8, D11–D20)
F17	To feel attracted by market demand	17	(D2–D10, D12, D14–D20)
F20	To have fun when developing an application	17	(D1–D5, D7–D11, D13–D19)
F22	To learn and improve skills	17	(D1–D3, D5, D7–D11, D13–D20)
F27	To self-manage workflow and pace	17	(D2–D4, D6–D11, D13–D20)
F21	To compete aiming to improve developer skills and intellect	16	(D1–D3, D7, D9–D20)
F8	To earn money through compensation or sales	15	(D1–D3, D5–D6, D8–D10, D14–D20)
F10	To face no barriers to access the market and sell the app	15	(D1, D3–D10, D12, D14, D17–D20)
F25	To feel satisfied about the relationship with the MSECO	15	(D3–D7, D10–D11, D13–D20)

Table 13
Factors that gained importance from starting to continuing participating in an MSECO.

ID	Factor	Initially	Now	Variation
F3	To have access to hardware with an acceptable performance	8	18	10
F19	To get support for the application entire life cycle	10	20	10
F23	To become recognized by the community	3	11	8
F7	To consider different user profiles	4	10	6
F15	To have the opportunity to get a nice job	13	19	6
F21	To compete aiming to improve developer skills and intellect	10	16	6
F26	To exchange knowledge between developers and community	14	20	6
F29	To enter a large and fair community of application developers	12	18	6

Table 14
Factor that lost importance from starting to continuing participating in an MSECO.

ID	Factor	Initially	Now	Variation
F18	To hardly lose money in MSECO	10	8	2

5.3. Changes on the perceptions of the factors based on the experience (RQ3)

We analyzed which factors have greater variation over time regarding their influence from starting to continuing participating in an MSECO, as pointed out by developers. The main factors that gained importance over time are presented in Table 13. The importance of the other factors did not change significantly. Only one factor lost importance from starting to continuing participating in an MSECO is presented in Table 14.

5.4. Main differences on the motivations to participate in Android and iOS MSECO (RQ4)

In order to answer this research question, we selected only developers who work exclusively on Android (6 developers) or iOS (5 developers). We did not use the answers from developers that work to both ecosystems because we would like to understand the major motivations of the developers of each MSECO.

Android MSECO. This ecosystem has been the biggest MSECO in terms of number of people within its community. The Android developers considered '(F6) To develop applications with built-in security features provided by the platform' as a very important factor to participate in an MSECO. It is considered unanimously important for both who starts and who continues participating in the Android MSECO. Other important factors considered by Android developers are: (F1) To contribute with new projects; (F2) To possess the desired technical resources; (F3) To have access to hardware with an acceptable performance; (F5) To have access to tools and guidelines to aid the design and development of the application user interface; (F15) To have the opportunity to get a nice job, (F19) To get support for the application entire life cycle; (F25) To feel satisfied about the relationship with the MSECO; (F26) To exchange knowledge between developers and community; and (F27) To self-manage workflow and pace. The less important factors according to the Android developers are: (F18) To hardly lose money in MSECO; (F7) To consider different user profiles; (F16) To believe in revenue share with MSECO; and (F23) To become recognized by the community.

iOS MSECO. This ecosystem is nurtured by loyal members who tend to invest considerably in the platform and has growing over time. The iOS developers considered '(F20) To have fun when developing an application' and '(F22) To learn and improve skills' as very important factors to participate in an MSECO. Other important factors considered by iOS developers are: (F1) To contribute with new projects; (F4) To setup easily the platform; (F12) To be

able to buy devices by a fair price; (F15) To have the opportunity to get a nice job; (F19) To get support for the application entire life cycle; (F21) To compete aiming to improve developer skills and intellect; (F26) To exchange knowledge between developers and community; (F27) To self-manage workflow and pace; and (F29) To enter a large and fair community of application developers. The only less important factor according to the iOS developers is: (F14) To adapt the developer application to several kinds of devices.

6. Discussion

The factors identified in this research can affect MSECO developers according to their profile, their needs and the ecosystem that contributes to generating solutions. In this section, we describe some perceptions on such factors.

6.1. Refined list of factors

Nowadays, only two MSECO are present in the global market, i.e., Android and iOS. These ecosystems usually take into consideration several factors identified in this research. These factors are discussed in the following:

- (F2) To possess the desired technical resources: Some developers point out that both Android and iOS are continuously improving their technical resources. It makes F2 less imperative to developers over time;
- (F3) To have access to hardware with an acceptable performance: Some experienced developers explain that F3 has improved, because MSECO manufacturers have produced better hardware;
- (F5) To have access to tools and guidelines to aid the design and development of the application user interface: Similar to F2, developers explain that both Android and iOS provide fair tools for related activities;
- (F8) To earn money through compensation or sales: Although it is an important factor, MSECO have clear rules that are recognized by developers with respect to income from application production or distribution;
- (F9) To get a great installed base over applications: Developers understand that Android or iOS have a huge installed base with customers;
- (F13) To select the channels to share the application: Android and iOS have their own official application stores and developers usually know how to use them when necessary;
- (F16) To believe in revenue share with MSECO: Developers have some confidence in both MSECO or in one of them, keeping them working;
- (F17) To feel attracted by market demand: Both ecosystems have a huge number of users and developers. Such developers get interested in participating in at least one MSECO;
- (F18) To hardly lose money in MSECO: In the past years, F18 would more present, but it is hard to see a developer losing money in an MSECO today;
- (F19) To get support for the application entire life cycle: Developers from both MSECO knows their resources to manage applications;
- (F21) To compete aiming to improve developer skills and intellect: Developers explain that both ecosystems are extremely competitive, because of a large offer of application solutions;
- (F24) To identify oneself with and feel committed with the community: Many developers are fans of the ecosystems they participate in, enjoying the work due to alignment with their philosophy;
- (F25) To feel satisfied about the relationship with the MSECO: Similar to F16, developers usually trust in MSECO and are often satisfied in their relationships;
- (F28) To choose a certain MSECO based on its advantages: Both Android or iOS MSECO provide several advantages to their developers, such as continuous improvement of resources;
- (F29) To enter a large and fair community of application developers: Developers explain about their relationships in their MSECO communities.

Although several factors are important, the two market-leading ecosystems usually have mechanisms to deal with them. This is recognized by developers from both MSECO.

6.2. Factors in Android MSECO

We noticed that factors somehow related to the technical dimension (e.g., F2, F3, F5, and F6) tend to be the most present in the motivations reported by developers who are participating only in the Android MSECO. This is because Android developers usually need to be more careful in the selection of tools, libraries and other resources, considering that many of them are developed from developers to developers as open source software. Moreover, Android developers point out a certain need for addressing factors related to the business and social dimensions. However, the mobile software industry brings great opportunities and the Android developer community is vast and welcoming. It has several forums, interest groups on specific technologies and also a great participation from the open source community.

6.3. Factors in iOS MSECO

iOS developers usually do not care so much about the technical dimension, since the company responsible for the ecosystem usually provides all the resources they need. Apple develops tools that improve the abstraction of concepts and make issues easy to handle in comparison with Android, in which it could take longer to solve or choose. In addition, developers who are participating only in the iOS MSECO often demand more factors related to the social dimension (e.g., F1, F20, F21, F22, F26, F27, and F29), which may suggest that the iOS community is more restricted, having a major influence from the company (keystone). However, they do not lead iOS developers to technical issues, since hardware/devices are all produced by the same company.

6.4. MSECO particularities

MSECO is a subset of SECO with a delimited context (mobile software) based on two great market leaders: (1) Android, which offer a platform that tends to be more open and retain more people; and (2) iOS, which offer a platform that tends to be more controlled and have users who invest more despite the number of users (Mallinson, 2015). In this scenario, some factors identified in this research are used to understand motivations to start or continue contributing to an MSECO, since such factors were analyzed particularly by MSECO developers (Fontão et al., 2015, 2016).

Analyzing the technical dimension, F2 could be seen as a factor that influence mobile and non-mobile software developers, but taking into account their specific perceptions on specific platforms and domains. F3 is more critical in mobile development, since it is more expansive to purchase an equipment with acceptable technical specifications to test new applications. F4 is a challenge both to mobile and non-mobile developers. The same happens in F5, but it could become even hard to set an application that could be adapted to a large variety of screen sizes in mobile

software development. F6 is important both to mobile and non-mobile developers. F7 should be more important to developers, but they recognize that projects used by different kinds of people (e.g., people with disabilities) are very uncommon.

Analyzing the business dimension, F8 is common to both contexts (mobile and non-mobile developers). F9 is more critical on mobile software development because such market is polarized between two great companies (Google and Apple), and non-mobile developers usually have other options of ecosystems depending on the technology they work on. F10 is hard to mobile developers because there are two market leaders to whom a developer needs to work with, accepting their barriers. F11 considers the fact that several developers would like to reach more users with their applications — somehow common to both mobile and non-mobile contexts. F12 was initially a financial barrier to mobile developers, because many of them had to purchase equipment to test their applications. In the non-mobile context, a developer usually just needs a computer to test an application. F13 could take a developer to a controversial feeling, firstly because of the two great market leaders, and of his/her sense of no choice. However, interviewees explained that developers learn how to deal with the ecosystem and has some freedom to choose after some time working on mobile development. F14 could be hardly found in the non-mobile context, but it is very common to the mobile context, because every device can have specific patterns. F15 and F16 are common to both contexts. F17 becomes greater nowadays since there is an increasing number of users of mobile technologies. F18 is pointed out by developers as usual in the past years, but currently it is very similar to the non-mobile context. F19 is considered important to mobile and non-mobile contexts.

Analyzing the social dimension, F1, F20, F21, F22, F23, F24, F25, F26, and F27 are common to both mobile and non-mobile contexts. F28 is more intense in the mobile context because of two scenarios (i.e., work with iOS or with Android). Finally, F29 is also common to both contexts.

7. Limitations

Some limitations and difficulties were faced as follows:

(i) The data analysis used the Card Sorting method, which is highly recommended in the case of clusters. However, since the amount of data collected was considerable, it took a great time for analysis;

(ii) The heterogeneity of the interviewees was not very high since the developers invited to the interviews are all Brazilians. A study with developers from several countries is necessary to have a more general view in order to strengthen the results obtained in this research;

(iii) Some developers may have agreed with the importance of factors. However, they may never have considered them until the time of the interview, i.e., with no reflection on the impact of the factors on their previous decisions;

(iv) The profile of the developers was not considered in details, such as grouping the results by time of experience, type of SECO in which each one participates in (e.g., open source, proprietary, or self-employed developers/employees), or even considering the projects they have contributed to. We searched for the similarity of placements, i.e., in some cases, a developer who participated in an MSECO only for one year has the same opinion of one with more than 5 years;

(v) The opinion of developers undergoes a maturation over time, so that even the most experienced interviewee can, at some point, reach new conclusions about the factors;

(vi) In order to determine the number of developers required for the 3rd study, the notion of saturation was applied, i.e., to interview developers until no new knowledge emerges from the interviews. However, since developers belong to one country (Brazil), perhaps developers from other countries could add new insights to the research;

(vii) The literature search covered MSECO. However, a more general literature review may present more technical factors that were not deeply explored in this research;

(viii) At the end of the 2nd study, we reduced the number of factors from 45 to 29. We removed 11 factors based on the opinion of MSECO experts, but we understand that this procedure can incur in a threat to validity. To mitigate that, we invited four experts who have large experience on real MSECO (iOS and Android) to analyze the results;

(ix) In this research, we did not have the intention to compare what factors are exclusive for Android or iOS. We have just collected a few insights from the MSECO developers.

8. Conclusion

This research focused on the identification of the factors that affect developers' decision to participate in an MSECO. To do so, three studies were conducted with the intention of understanding: (1) what factors the literature presents; (2) which of them can be significant for real MSECO; and (3) how MSECO developers realize them from starting to continuing participating in an MSECO. This research allowed us to identify that (1) a developer thinks in a few factors when starting than when continuing participating in an MSECO; (2) the MSECO market offers several opportunities for developers, and (3) developers have used their creativity to discover new ways to earn money, improve skills and feel satisfied with their careers.

Moreover, this research helps to fill in some gaps presented in the MSECO literature so far, such as the lack of studies focusing on developers, not just on technologies or business rules of the ecosystem. Thus, this research opens opportunities for future work. A future study should investigate how the list of factors affect developers considering the different industries, with different employment status or different types of organizations, as well as developers in different career stages (e.g., difference between early- and mid-career). In addition, we suggest an opportunity to conduct a quantitative study to understand how those factors are realized by developers from different types of SECO.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix. List of factors and definitions

F1 — To contribute with new projects. Some developers feel the need for creating new and innovative projects since the current applications in the market do not solve the developers' own needs or any existing demand from the community.

F2 — To possess the desired technical resources. An MSECO provides openness, a set of tools, and technical elements to assist developers in building applications. Examples of these elements are: a development kit; APIs and programming languages; documentation and support from the MSECO keystones, cross-platform compatibility features, and multiple device models; tools to support team development; development environments that are adaptable to the developers needs; features to help control application scalability; support to diverse development methodologies; application maintenance resources; the ability to import extension resources such as libraries and external codes; app design resources and tutorials on getting the app in the store; licenses to use these features; and access to native codes and support for auxiliary devices.

F3 — To have access to hardware with an acceptable performance. When creating an application, a developer wants to be able to run it on different devices without losing its performance and having the ability to adapt it to different hardware standards. For example, it is important to analyze metrics, such as average battery consumption and performance.

F4 — To setup easily the platform. The platform is quickly configurable, a developer is free to configure it as he/she wants, and there is no need to go through unnecessary steps for such configurations. It should require a short time and little technical knowledge from an MSECO developer.

F5 — To have access to tools and guidelines to aid the design and development of the application user interface. To provide a user with a good experience in an application, it is important that the MSECO platform offers standardization resources for developers design and build user interfaces with as little effort as possible and aligned with the platform design standards. Thus, a developer requires tools and guidelines to work.

F6 — To develop applications with built-in security features provided by the platform. Platforms can support in-app security at multiple levels. Mobile platforms are often restrictive in access permissions. For instance, requesting permissions on-demand increases an application's perceived security. Data loss can be prevented by using on-device data encryption mechanisms as well as secure data transfer protocols against eavesdropping. The platform development framework can provide validation of user input and prevent spoofing and cross-site code injection.

F7 — To consider different user profiles. Cross-platform applications can support ways of handling user profiles, ranging from purely local applications to user accounts on multiple devices and role-based authentication.

F8 — To earn money through compensation or sales. A developer remuneration can come from two different payment strategies: through a compensation of the work done by developing an application (e.g., salary), or through the money made by selling an application. In the latter, the platform must offer different models of monetization of applications so that a developer can choose the one that best fits his/her needs for profitability.

F9 — To get a great installed base over applications. The size of the installed base of an MSECO is relative to the number of users who purchase applications or services. The larger the installed base of an MSECO (as well as the participation of users), the more possibilities to promote the sale of applications.

F10 — To face no barriers to access the market and sell the app. Provide easy access to the market, including tool kits and support for developers, license to use and an efficient way of distribution. Moreover, low barriers to entry are offered: low monetary and technical requirements, and affordable application certificates, for example.

F11 — To have penetration in the applications market. This refers to which extent an MSECO has market penetration and thus enables commercialization, leading developers to envision sale of their applications.

F12 — To be able to buy devices by a fair price. Devices belonging to an MSECO need to be sold by a reasonable price to allow both users and developers to afford buying them. Developers often need these devices to test applications. They can also support the development itself.

F13 — To select the channels to share the application. A developer must be free to choose which available channels for distribution of applications he/she wants to use. The selected channels should assist developers make some income from them, as well as develop reputation, career and portfolio. They should be also easy to use for publishing applications. Another desirable feature is to offer the chance of distributing applications over the world, which may delimit geographic regions for application availability.

F14 — To adapt the developer application to several kinds of devices. An MSECO is open to allow different device models to be marketed with the respective operating system. Likewise, the operating system should easily fit different device models. The more devices use an operating system, the more users reach applications.

F15 — To have the opportunity to get a nice job. The market offers opportunities and a growing number of demands from users or companies. Thus, when a developer makes an application available, users or companies can easily use it. Such a perspective might attract developers to maintain and evolve applications.

F16 — To believe in revenue share with MSECO. MSECO keystones work on the developer's interests. These companies respect contracts with developers since MSECO policies are trustworthy and revenue distribution from sales to the developers is attractive.

F17 — To feel attracted by market demand. Users search for and use services that developers make available in the MSECO store. The users' demands are intense and a large number of users are willing to pay for applications or subscribe to periodic services that meet their demands.

F18 — To hardly lose money in MSECO. If a developer needs to leave an MSECO, he/she will have trivial losses. A developer may stop his/her collaboration with an MSECO at any time. He/She will stay for as long as he/she perceives it as profitable.

F19 — To get support for the application entire life cycle. The MSECO platform should supports the application entire life cycle, including starting up, production, distribution, and maintenance. Such support should consider statistics that might be of help for the application management.

F20 — To have fun when developing an application. Some developers enjoy having fun when contributing to and feel pleasure in the development process. This intrinsic motivation expresses

the developer's personality and interest in participating in the production process of an application.

F21 — To compete aiming to improve developer skills and intellect. A developer is motivated to collaborate aiming to improve his/her skills and because he/she wants to intellectually challenge himself/herself. There is a feeling of pushing boundaries. A developer also perceives the competition with others as an attempt to create more efficient solutions.

F22 — To learn and improve skills. Developing programming skills and learning how to make applications better end up motivating some developers. The learning curve needs to be short to avoid discouraging developers.

F23 — To become recognized by the community. The developer's reputation gain in an MSECO community is a strategy to demonstrate innovations he/she has implemented via applications. A developer can become known not only by his/her deployed applications but also by sharing successful source code, technical documentation, tutorial videos, and answering questions in forums. This reputation is part of ones' portfolio.

F24 — To identify oneself with and feel committed with the community. An MSECO that has a development community engaged in helping others makes developers feel welcomed. It also create the sense of identification and contribution to support others.

F25 — To feel satisfied about the relationship with the MSECO. A developer is loyal and keeps collaborating with an MSECO when he/she respects the ecosystem keystone, considers the platform pleasant, and has a market that offers demands to be addressed. As such, a developer can feel connected to an MSECO he/she contributes to.

F26 — To exchange knowledge between developers and community. A developer engages in exchanging knowledge with others by using online forums and participating in conferences, for instance. This improves his/her performance, productivity, and effectiveness in the development process. It also promotes inclusion and collaboration with the developers' community.

F27 — To self-manage workflow and pace. The possibility of self-managing performance, work processes and production pace instead of having to obey to a report chain (such as corporate control) strengthens the relationships between developers and MSECO. It provides a developer with a sense of satisfaction with his/her work.

F28 — To choose a certain MSECO based on its advantages. A developer chooses a certain MSECO to contributes to, given the advantages that can be perceived, such as better profitability, quality development resources, more active support community etc.

F29 — To enter a large and fair community of application developers. The size and quality of the developers' community enacts the perception of belonging to a supporting community, i.e., receiving help when needed.

References

Al-Hinai, N., Piya, S., Al-Wardi, K., 2020. Analysis of factors affecting motivation in projects: A case study in oil and gas industry in Oman. J. Eng. Res. 17 (2), 112–125.

Baddoo, N., Hall, T., Jagielska, D., 2006. Software developer motivation in a high maturity company: a case study. Softw. Process: Improv. Pract. 11 (3), 219–228.

Beecham, S., Baddoo, N., Hall, T., Robinson, H., Sharp, H., 2008. Motivation in Software Engineering: A systematic literature review. Inf. Softw. Technol. 50 (9–10), 860–878.

Bosch, J., 2009. From software product lines to software ecosystems. In: Proceedings of the International Software Product Line Conference. ACM, San Francisco, USA, pp. 111–119.

Bosch, J., Bosch-Sijtsema, P., 2010. From integration to composition: On the impact of software product lines, global development and ecosystems. J. Syst. Softw. 83 (1), 67–76.

Campbell, P., Ahmed, F., 2010. A three-dimensional view of software ecosystems. In: Proceedings of the European Conference on Software Architecture: Companion Volume, Vol. 1. ACM, Copenhagen, Denmark, pp. 81–84.

Choi, G., Nam, C., Kim, S., 2017. The impacts of mobile platform openness on application developers' intention to continuously use a platform: From an ecosystem perspective. In: Proceedings of the International Telecommunications Society. EconStorn, Passau, Germany, pp. 1–28.

Choi, G., Nam, C., Kim, S., 2018. The impacts of technology platform openness on application developers' intention to continuously use a platform: From an ecosystem perspective. Telecommun. Policy 42, 1–14.

Costa, L.A., Fontão, A., Santos, R., 2021. Investigating proprietary software ecosystem governance and health: An updated and refined perspective. In: Proceedings of the Brazilian Symposium on Information Systems. Uberlândia, Brazil, pp. 1–8.

Creswell, J.W., 1998. Qualitative Inquiry and Research Design: Choosing Among Five Tradition. Sage.

de Souza, C.R., Figueira Filho, F., Miranda, M., Ferreira, R.P., Treude, C., Singer, L., 2016. The social side of software platform ecosystems. In: Proceedings of the Conference on Human Factors in Computing Systems. ACM, San José, USA, pp. 3204–3214.

Deniz, S., Kehoe, F., 2013. Fostering Innovation: Factors that Attract and Retain Third Party Developers in Mobile Ecosystems (Master's thesis). Lund University, Sweden.

Dhungana, D., Groher, I., Schludermann, E., Biffl, S., 2010. Software ecosystems vs. natural ecosystems: Learning from the ingenious mind of nature. In: Proceedings of the European Conference on Software Architecture: Companion Volume. ACM, pp. 96–102.

Dobrica, L., Pietraru, R., 2017. Experiencing native mobile health applications development. In: Proceedings of the International Conference on Control Systems and Computer Science. IEEE, Bucharest, Romania, pp. 523–528.

dos Santos, R.P., Werner, C.M.L., 2011. A proposal for software ecosystems engineering. In: Proc. of the International Workshop in Software Ecosystems. ICSOB, Brussels, Belgium, pp. 40–51.

Ferreira, R., 2016. Um Estudo Exploratório dos Fatores de Adoção de Plataformas de Software Móveis (Master's thesis). UFPA, Brazil.

Flick, U., 2014. An Introduction to Qualitative Research. Sage.

Fontão, A.d.L., Dias-Neto, A., Santos, R., 2017. Towards a guideline-based approach to govern developers in mobile software ecosystems. In: Proceedings of the Mastering Scale and Complexity in Software Reuse. Springer, Salvador, Brazil, pp. 208–213.

Fontão, A.d.L., dos Santos, R.P., Dias-Neto, A.C., 2015. Mobile software ecosystem (MSECO): A systematic mapping study. In: Proceedings of the IEEE Annual Computer Software and Applications Conference. IEEE, Taichung, Taiwan, pp. 653–658.

Fontão, A., Santos, R., Dias-Neto, A., et al., 2016. MSECO-DEV: Application development process in mobile software ecosystems. In: Proceedings of the International Conference on Software Engineering and Knowledge Engineering. Knowledge Systems Institute, Redwood City, USA, pp. 317–322.

França, A.C.C., de Araújo, A.C., Da Silva, F.Q., 2013. Motivation of software engineers: A qualitative case study of a research and development organisation. In: Proceedings of the International Workshop on Cooperative and Human Aspects of Software Engineering. IEEE, San Francisco, USA, pp. 9–16.

França, C., Da Silva, F.Q., Sharp, H., 2018. Motivation and satisfaction of software engineers. IEEE Trans. Softw. Eng. 46 (2), 118–140.

França, A.C.C., Gouveia, T.B., Santos, P.C., Santana, C.A., da Silva, F.Q., 2011. Motivation in software engineering: A systematic review update. In: Proc. of the Conference on Evaluation & Assessment in Software Engineering. IET, Las Vegas, USA, pp. 154–163.

Gerosa, M., Wiese, I., Trinkenreich, B., Link, G., Robles, G., Treude, C., Steinmacher, I., Sarma, A., 2021. The shifting sands of motivation: Revisiting what drives contributors in open source. In: Proceedings of the International Conference on Software Engineering. IEEE, Madrid, Spain, pp. 1046–1058.

Goldbach, T., Benlian, A., 2015. Understanding informal control modes on software platforms–the mediating role of third-party developers' intrinsic motivation. In: Proc. of the International Conference on Information Systems. AISeL, Las Vegas, USA, pp. 1–20.

Goldbach, T., Benlian, A., Buxmann, P., 2017. Differential effects of formal and self-control in mobile platform ecosystems: Multi-method findings on third-party developers' continuance intentions and application quality. Inf. Manage. 55, 271–284.

Greiler, M., Storey, M.-A., Noda, A., 2022. An actionable framework for understanding and improving developer experience. IEEE Trans. Softw. Eng. X (X), 1–15.

Guest, G., Bunce, A., Johnson, L., 2006. How many interviews are enough? An experiment with data saturation and variability. Field Methods 18 (1), 59–82.

Hall, T., Sharp, H., Beecham, S., Baddoo, N., Robinson, H., 2008. What do we know about developer motivation? IEEE Softw. 25 (4), 92–94.
Jansen, S., Finkelstein, A., Brinkkemper, S., 2009. A sense of community: A research agenda for software ecosystems. In: Proceedings of the International Conference on Software Engineering: Companion Volume. IEEE, Boston, USA, pp. 187–190.
Kim, H.J., Kim, I., Lee, H., 2016. Third-party mobile app developers' continued participation in platform-centric ecosystems: An empirical investigation of two different mechanisms. Int. J. Inf. Manage. 36, 44–59.
Kitchenham, B., Charters, S., 2007. Guidelines for Performing Systematic Literature Reviews in Software Engineering, Vol. 2. Software Engineering Group Department of Computer Science Keele University, pp. 512–523.
Koch, S., Guceri-Ucar, G., 2017. Motivations of application developers: Innovation, business model choice, release policy, and success. J. Org. Comput. Electron. Commer. 27, 218–238.
Koch, S., Kerschbaum, M., 2014. Joining a smartphone ecosystem: Application developers' motivations and decision criteria. Inf. Softw. Technol. 56 (11), 1423–1435.
Mallinson, K., 2015. Smartphone revolution: Technology patenting and licensing fosters innovation, market entry, and exceptional growth. IEEE Consum. Electron. Mag. 4 (2), 60–66.
Manikas, K., Hansen, K.M., 2013. Software ecosystems – A systematic literature review. J. Syst. Softw. 86 (5), 1294–1306.
Miranda, M., Ferreira, R., de Souza, C.R., Figueira Filho, F., Singer, L., 2014. An exploratory study of the adoption of mobile development platforms by software engineers. In: Proceedings of the International Conference on Mobile Software Engineering and Systems. ACM, Hyderabad, India, pp. 50–53.
Oliveira, R., Ajala, C., Viana, D., Cafeo, B., Fontão, A., 2021. Developer Relations (DevRel) roles: an exploratory study on practitioners' opinions. In: Proceedings of the Brazilian Symposium on Software Engineering. ACM, Joinville, Brazil, pp. 363–367.
Petersen, K., Feldt, R., Mujtaba, S., Mattsson, M., 2008. Systematic mapping studies in software engineering. In: Proceedings of the Evaluation and Assessment in Software Engineering Conferece. Bari, Italy, pp. 68–77.
Ribeiro, B.B., Costa, C., Pereira dos Santos, R., 2022. Understanding and analyzing factors that affect merge conflicts from the perspective of software developers. J. Softw. Eng. Res. Dev. 10, 12:1 – 12:17.
Rieger, C., Majchrzak, T.A., 2016. Weighted evaluation framework for cross-platform app development approaches. In: Proceedings of the EuroSymposium on Systems Analysis and Design. Springer, Gdansk, Poland, pp. 18–39.
Ryu, M.H., Kim, J., Kim, S., 2014. Factors affecting application developers' loyalty to mobile platforms. Comput. Hum. Behav. 40, 78–85.
Sadi, M.H., Dai, J., Yu, E., 2015. Designing software ecosystems: How to develop sustainable collaborations? In: Proceedings of the Advanced Information Systems Engineering Workshops. Springer International Publishing, Stockholm, Sweden, pp. 161–173.
Schaarschmidt, M., Homscheid, D., Kilian, T., 2019. Application developer engagement in open software platforms: An empirical study of Apple iOS and Google Android developers. Int. J. Innov. Manag. 23 (4), 1–33.
Schoeffel, P., Wazlawick, R.S., Ramos, V.F.C., 2018. Motivation and engagement factors of undergraduate students in computing: A systematic mapping study. In: Proceedings of the IEEE Frontiers in Education Conference. IEEE, San José, USA, pp. 1–5.
Seaman, C.B., 2008. Qualitative methods. In: Shull, F., Singer, J., Sjoberg, D.I. (Eds.), Guide to Advanced Empirical Software Engineering. Springer, pp. 35–62, Ch. 2.
Singer, J., Sim, S.E., Lethbridge, T.C., 2008. Software engineering data collection for field studies. In: Shull, F., Singer, J., Sjoberg, D.I. (Eds.), Guide to Advanced Empirical Software Engineering. Springer, pp. 9–34, Ch. 1.
Spencer, D., 2009. Card Sorting: Designing Usable Categories. Rosenfeld Media.
Steglich, C., Marczak, S., De Souza, C.R.B., Guerra, L.P., Mosmann, L.H., Figueira Filho, F., Perin, M., 2019a. Social aspects and how they influence MSECO developers. In: Proceedings of the International Workshop on Cooperative and Human Aspects of Software Engineering. IEEE, Montreal, Canada, pp. 99–106.
Steglich, C., Marczak, S., Guerra, L.P., Mosmann, L.H., Perin, M., Figueira Filho, F., De Souza, C., 2019b. Revisiting the mobile software ecosystems literature. In: Proceedings of the International Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems. IEEE, Montreal, Canada, pp. 50–57.
Steglich, C., Marczak, S., Santos, R., Mosmann, L.H., Guerra, L.P., De Souza, C., Filho, F.F., Perin, M., 2020. How do business factors affect developers in mobile software ecosystems? In: Proceedings of the Brazilian Symposium on Information Systems. SBC, São Bernardo do Campo, Brazil, pp. 1–8.
Steglich, C., dos Santos Marczak, S., Santos, R., Guerra, L.P., Mosmann, L.H., de Souza, C., Perin, M., et al., 2019c. How do technical factors affect developers in mobile software ecosystems. In: Proceedings of the Workshop on Software Visualization, Evolution and Maintenance. SBC, Salvador, Brazil, pp. 58–65.
VanAntwerp, J.J., Wilson, D., 2018. Differences in motivation patterns among early and mid-career engineers. J. Women Minor. Sci. Eng. 24 (3), 227–259.
Wohlin, C., 2014. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In: Proceedings of the International Conference on Evaluation and Assessment in Software Engineering. ACM, London, United Kingdom, p. 38.