Wealthy, Healthy and/or Happy — What does 'Ecosystem Health' Stand for?

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Abstract. The health of a software ecosystem is argued to be a key indicator of well-being, longevity and performance of a network of companies. In this paper, we address what scientific literature actually means with the concept of 'ecosystem health' by selecting relevant articles with systematic literature review. Based on the final set of 38 papers, we found that despite a common base, the term has been used to depict a wide range of hoped characteristics of a software ecosystem. However, the number of studies addressing the topic is shown to grow while empirical studies are still rare. Thus, further studies should aim to standardize the terminology and concepts in order to create a common base for future work. Further work is needed also to develop early indicators that warn and guides companies on problems with their ecosystems.

Keywords: Software ecosystem · Ecosystem health · Business ecosystem · Systematic literature study

1 Introduction

'Business ecosystem' analogy, by Moore [1,2], and its derivatives—such as 'software ecosystem'—are crucial conceptualizations for modern-day business networks. Business ecosystems, formed by firms, are seen everywhere. For example, there are several different kind *software ecosystems* (SECO) focusing on the software producing companies and their networks [3,4], *mobile ecosystems* formed by the companies producing hardware and software for new era smartphones [5], and even *mobile application ecosystems* that focus on the relationship of mobile application marketplaces and their content producers and users [6]. In this paper, we see 'software ecosystem' as a special case of more general 'business

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ecosystem' concept. That is, a software ecosystem is a-kind-of business ecosystem. While our focus in this paper is on the former, we acknowledge and use the extant knowledge of the latter.

A common approach to both the business and software ecosystem research agendas is to define a measure of *healthiness* for an ecosystem. Iansiti & Levien [7,8] state that, similarly as in a biological ecosystem, that the survival of individual actors within an ecosystem are dependant on the whole network rather than the strength of the actor itself. This creates the assumption that the health of the ecosystem is crucial for all actors joined to the ecosystem.

The concept of 'ecosystem health' is important also for software ecosystems. In this paper, we address the existing research on the concept of 'ecosystem health' in the field of software ecosystem research. We use a systematic literature review (SLR) to select papers focusing on the topic and follow Kitchenham & Charter's [9] guidelines of conducting a SLR. From the selected papers, we analyse how the term is used and defined. The research questions of the paper are:

RQ1. Is there increasing scholarly interest towards 'ecosystem health'?

RQ2. Has the scholarly debate resulted in a common understanding on the definition?

RQ3. What are the characteristics, actors and agents mentioned in literature that have an influence to ecosystem health?

RQ4. Is there empirical evidence to support definitions or characteristics found in literature?

The research questions use the systematic literature review approach to quantify the need for an discussion on ecosystem health—i.e., is this a topic of interest in the scholarly debate. The research questions also formulate the status of scholarly debate—i.e., is there a consensus on the framework and relevance of ecosystem health. Finally, this study strives to uncover sufficient empirical evidence for whatever theoretical findings has been gathered.

Previously, Manikas & Hansen [10] studied ecosystem health with a literature survey. In the article, they construct a software ecosystem framework. However, their paper relies on a few years old dataset that contains only 13 articles related to software ecosystem health. Our set contains three times more articles, and, instead of constructing an ecosystem health model, we are interested on the discussion of and the recent development in the area of software ecosystem health. This paper contributes to the field by showing a multitude of meanings associated with the term and proposing new research avenues. This paper request further work to normalize the ongoing discussion and research of software ecosystem health.

The rest of the paper is structured as follows. The following section will give a brief introduction to the ecosystem health. It is followed by the depiction of research methods in Section 3, results and analysis in Section 4. Section 5 presents discussion of the meaning of results and Section 6 concludes the study.

2 Background

In this section, we will present the software ecosystem health model by Manikas & Hansen [10], and the classical view of business ecosystem health by Iansiti & Levien [7,8]. Due to the space limitations, we do not discuss on the definition of software ecosystem or its actors but refer the interested readers to recent literature reviews [6,11].

In their work, Manikas & Hansen [10] make a categorization about ecosystem health related literature, in order to find definitions for software ecosystem health. They create four categories: software ecosystems (main category) and business ecosystems, natural ecosystems and open source software. Literature from all categories draws from the main category's definition. Nevertheless, there is one main difference between the main category and the rest: nature of the ecosystem's production. While other ecosystems see actors as products themselves, software ecosystem, according to Manikas & Hansen [10], makes a difference between the actor in ecosystem and the production of ecosystem [10].

In software ecosystem, according to Manikas & Hansen [10] health of an actor and of a product are separated, not affecting each other, whereas in natural and business ecosystems, health of an actor affects the product's health. That independence of actor's and product's health in software ecosystems can appear in form of an excellent software product or platform having positive effect on health of the ecosystem, while the actor who created that product has a negative effect on health through defects in its business model [10].

Ecosystems are also defined by the roles and awareness of roles by different actors. A differentiator between software ecosystems and other mentioned types of ecosystems is an orchestrator that creates the rules and runs the platform that is used in that specific ecosystem [10]. Also the consciousness of the existence of an ecosystem and belonging to it makes a difference between natural and artificial ecosystems [2]. Awareness of ecosystem's actors about the ecosystem affects their acts in it, and should therefore be taken into account when defining the health of an ecosystem.

Base-creating definition of measures to be used when addressing health of ecosystems, both business and biological was presented by Iansiti & Levien [7,8]. They propose that ecosystem health should be measured by *productivity*, *robustness* and *niche creation* [7]:

Productivity can be measured in business or software ecosystems, e.g., in return on invested capital; how much value is created turning tangible and intangible assets into production. In natural ecosystems measure, can be, e.g., biomass created using inputs like sunlight.

Robustness in its simplest form, according to Iansiti & Levien [7], is measured in survival rate of ecosystem's members, either in relation to other ecosystems or over time. Robustness means that the ecosystem can face and survive from the changes of the environment.

Niche Creation in business context refers to ability to create value by putting new functions into operation and increasing meaningful diversity in

ecosystem through that. Diversity gives ecosystem potential for productive innovation and indicates its ability to absorb shocks from outside. [7]

In addition to these health measures, there are several different characteristics argued to be included into the 'ecosystem health' concept. For example, Hyrynsalmi *et al.* [12] argues that satisfaction of actors involved in an ecosystem should be considered.

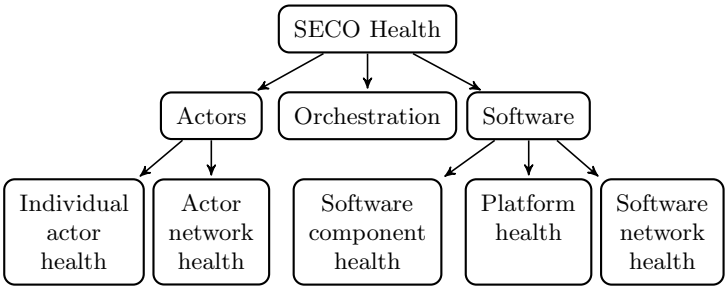

Fig. 1. A breakdown of the SECO health framework [10, adapted]

Software ecosystem health –model proposed by Manikas & Hansen [10] divides health of an ecosystem to three main components: actors, software and orchestration (Figure 1). This model, as it name specifies, is prepared taking into account earlier mentioned features that differentiate software ecosystems from other ecosystems; the separation of actor health and product health, and the existence of and orchestrator. In the model, actor component is further divided to *individual actor health* and *actor network health*. Software component in turn consists of *software component health*, *platform health* and *software network health*. Descriptions of these subcomponents according to Manikas & Hansen [10] are shortly presented below:

Individual Actor Health. Productivity and robustness mentioned by Iansiti & Levien [7] are the main building blocks of an individual actor's health in an ecosystem. Actively participating an actor probably is a robust member of an ecosystem and most likely has its place in it in the future also.

Actor Network Health. Interaction within an actor's network affects the ecosystem's health. The role of an actor in a network increases or decreases its effect on the health of an ecosystem. Key player, even with lower productivity, means more to ecosystem health than high productivity from a niche player.

Software Component Health. In case of software ecosystem, the software component is most likely a product of the ecosystem. Its health can be measured, e.g., in terms of reliability, availability, modifiability and interoperability. Software component health is affected by its relative demand and quality.

Platform Health. Platform health can be similarly analyzed as software component health, platform being a software component also. It might still have

effect also on orchestration of the software ecosystem. If so, measuring platform health should include a measure for the effectiveness of orchestration actions.

Software Network Health. Interaction between software components can be measured and categorized. Connected software components form a network, which health can be measured by e.g. looking at the key players' role in it; whether they are enabling interaction or trying to dominate whole network's actions.

Orchestration Influence on Health. Orchestrator can have a role of 'caretaker' of an ecosystem; using measures like health of an ecosystem to monitor it and take actions if needed. Orchestrator can influence the ecosystem e.g. by setting rules, communicating plans, managing the platform, controlling number of actors and affecting internal products revenue model.

In relation to orchestrator's role, Iansiti & Levien [7] are of the opinion that the orchestrator's aim should be improving the health of the whole ecosystem. Effective orchestrator or key player should create and share value in ecosystem in order to tempt actors to join and keep existing actors satisfied. [7]

Orchestrator can damage the ecosystem health by being a physical dominator or value dominator, warn Iansiti & Levien [7]. An ecosystem can be suppressed by an orchestrator who aims to directly managing big part of the network or made unsustainable by an orchestrator that draws majority of value created within ecosystem to itself. [7]

In conclusion, 'ecosystem health' is defined through the network dynamics of the participating actors. Previous research emphasizes the relevance of roles, specifically that of the orchestrator, and that individual actors health is always derived from the benefit of the ecosystem. In the following, we will study how widely these definitions are used in the software ecosystem health literature and what is the strength of empirical evidence.

3 Method

We used SLR as a data collection method in this study and followed Kitchenham & Charters' [9] guidelines of conducting data collection. Due to the wide-spread popularity of the topic, we decided to use an electronic search–in contrast to a manual search where researchers read through selected journals and publication series–to large article databases. In each search engine, we used the search term `"software ecosystem" AND health`. Searches were targeted to full texts, and only research papers (i.e., peer-reviewed articles) were included when it was possible to select.

We used the following databases in this study (the number of hits is given in the brackets):

1. ACM Digital Library (43)
2. IEEE Xplore Digital Library (45)
3. ScienceDirect (33)
4. ISI Web of Science (4)

5. Proquest (9)
6. Wile Online Library (8)
7. SpringerLink (58)

The searches were done in January 15th, 2014. In total, we collected 194 unique articles in the first phase with the above-mentioned search term.

In the second phase of the review process, we went through all unique papers and kept those which dealt with a) 'software ecosystem' and b) 'ecosystem health'. Only articles written in English were included. Articles which were not published in a scientific peer-reviewed venue were excluded. Furthermore, we excluded posters, editorials, presentation notes and panel summaries. These were the only inclusion or exclusion criteria used. After the second phase, 38 articles were included into the dataset.

In the final phase, all selected articles were gone through. From each paper, we extracted how the concept 'ecosystem health' was used, were there any synonyms for it and did the paper name any sources for the ecosystem health discussion. The study is based on the quantitative analysis of the results and the qualitative discussion of the implications. The results are discussed in the following section.

4 Results and Analysis

Table 1 shortly summarizes the selected papers' view on the concept of 'ecosystem health'. The column 'Uses empirical data?' classifies if the article used empirical data. In this, we require that the empirical study of a paper is directly related to ecosystem health, and that the authors explicitly state the relationship between results and health as a whole. For example, the article by Hyrynsalmi et al. [53] is not, in this study, classified as empirical: the study is justified with the ecosystem health, but it forgot ecosystem health concept when analysing and discussing its results.

Table 1. The papers selected to this literature review with a short summary

ID	Description how a paper considers the 'ecosystem health' concept	Uses empirical data?
[13]	Uses three different views to analyze a SECO. In addition to transaction and structure analyses, the model of [14] is used to analyze the health of a SECO. Proposes simple measures for Robustness, Productivity and Niche creation; e.g., a number of downloads as a an indicator of Robustness and a number of commits as a measure of Productivity.	No
[15]	The diversity of actors (developers) supports ecosystem health. Dominators are harmful for an ecosystem as they reduce the diversity. Follows [8] in view of ecosystem health.	No
[16]	Software ecosystem modeling might help to evaluate health of an ecosystem. Follows [17,7] in a view of ecosystem health.	No
[18]	Argues that a community (of developers, experts and users) is vital for the health of a SECO and that a keystone player's mission is to promote the overall health of an ecosystem.	No
[19]*	Proposes a set metrics for ecosystem health by instantiating the software ecosystem health framework of [10]. The empirical part is based on a qualitative analysis of a case ecosystem.	No
[20]	Based on the interviews, shows that software vendors select an ecosystem based on its health, which is seen as a performance indicator of an ecosystem. Follows [7,8] in a view of ecosystem health.	No

*An article's main focus is in the concept of 'ecosystem health'

Table 1. *(Continued from previous page)*

ID	Description how a paper considers the 'ecosystem health' concept	Uses empirical data?
[21]	Notes that low socio-technical congruence might be harmful for health of a software ecosystem.	No
[22]	Argues that software ecosystem modeling might help to visualize ecosystem health and stability.	No
[23]	Discusses on health of e-learning software ecosystem. Follows [8] view of ecosystem health.	No
[24]	Uses the 'biological ecosystem' concept as a starting point and argues that healthy ecosystem requires proper feedback (from technical issues, business considerations and community participation) and management. A healthy ecosystem survives even when losing a part of its population. A healthy community (of an ecosystem) is "sustainable, livable, equitable and prosperous."	No
[25]	Health of an ecosystem describes the performance of the ecosystem. 'SECO biology' (i.e., composition), 'Lifestyle' (e.g., vision, entry barrier, openness), 'Environment' (i.e., stakeholders) and 'Health Care Organization' (banks, investors, governments etc.) can affect to ecosystem health. Follows [8] in a view of health.	Yes
[26]*	Studies how meritocracy affects to health of an ecosystem. Follows [7,27] in a view of health; measures productivity with number of commits.	Yes
[28]	Determinants of ecosystem health are productivity of and value creation by its actors. Productivity is measured with commits, LOCs, number of active partners. In a view of ecosystem health, follows [7,29].	No
[30]	Sees 'ecosystem health' as a knowledge flow (similar to a nutrient recycling process in a biological ecosystem); 'ecosystem sustainability' is defined as keystone activities to maintain the community.	No
[31]	Characteristics of ecosystem health include, at least, growth and evolution over time. The paper argues that a growth rate is a good indicator of ecosystem health.	No
[32]	Follows [7] in the view of ecosystem health.	No
[33]	Health of a project is related to health of an ecosystem; i.e., the quality of a project affects health of ecosystem and vice versa.	
[34]	Sustainability and diversity are health indicators of an ecosystem.	No
[35]	Sustainability and diversity are health indicators of an ecosystem. Furthermore, actors in an ecosystem have impacts on SECO health.	No
[36]	From technical dimension, a SECO's central platform could be analysed with productivity, robustness and niche creation. From business dimension, sustainability and diversity are health indicators of a SECO.	No
[37]	A healthy ecosystem is generating revenue (for developers).	No
[27]*	The paper focuses on the open-source software ecosystem and it notes that project health is not same than the ecosystem health. A healthy unit should be, e.g., lively, active, long-living; in the study longevity and a propensity for growth were the main characteristics. The study presents an open-source software health framework with proposed measures for different characteristics. The model has two dimensions; the scope dimension has three levels (theory, network level and project level) and the other dimension consists of productivity, robustness and niche creation.	Yes
[11]	In a large systematic literature study, the authors identified an emerging research line (13 articles) on ecosystem health. According to the article, a healthy SECO is functioning well. They also point out that while diversity is often argued to contribute ecosystem health through richer niche creation, there are no concrete studies to validate this hypothesis. Similarly, the authors note that there are few studies concretely measuring, analyzing or elaborating health of a software ecosystem.	No
[38]	Development of metrics for measuring ecosystem health is mentioned as an existing challenge.	No
[39]	'Ecosystem health' and 'ecosystem sustainability' concepts are seen capturing the same phenomenon. Commitment of actors to the ecosystem improves sustainability (i.e., health of an ecosystem). Further, authors suggest evaluating ecosystem health when analysing and designing an ecosystem.	No
[40]	Ensuring health of their ecosystems is seen as a responsibility of keystones.	No
[41]	Health of an individual actor depends heavily on health of a complete network (i.e., ecosystem). Follows [7] in a view of ecosystem health. A keystone player's actions stimulate health of the entire ecosystem. The paper proposes development of a software ecosystem health model.	No

*An article's main focus is in the concept of 'ecosystem health'

Table 1. *(Continued from previous page)*

ID	Description how a paper considers the 'ecosystem health' concept	Uses empirical data?
[42]	An ecosystem have to be healthy to be a long-living one. Follows [7] in a view of ecosystem health.	No
[43]	An ecosystem architecture can pose risks that endangers health of the entire ecosystem; an architectural analysis of the ecosystem can reveal health threats.	
[44]	Ecosystem governance leads to better ecosystem performance and health.	No
[45]*	To survive, an ecosystem should be healthy. In a healthy ecosystem, a participating firm can achieve its financial goals easier than in any other ecosystem. The study extends [7] view of ecosystem health; health of a software ecosystem is measured with robustness, productivity, interoperability, stakeholder's satisfaction and creativity. The model is empirically tested with a survey on Tunisian software ecosystem.	Yes
[46]	Motivating joined developers to work together (i.e., increase the interconnectivity) would improve ecosystem health.	No
[47]*	Ecosystem governance is argued to have an impact on ecosystem health. The paper studies Ecosystem Governance Model by [48,49] and follows [8] in the view of ecosystem health. The authors' note that the results from a case study might indicate early sign of low ecosystem health; however, the studied ecosystem is considered to be a growing one.	Yes
[50]	To be able to create value, a keystone's responsibility is to ensure a healthy and sustainable ecosystem. Follows [7] in an view of ecosystem health. Notes that 'sustainability' and 'ecosystem health' are closely linked performance objectives.	No
[51]	Health is a characteristic of an ecosystem. In a healthy SECO, there are two main roles that an actor can take: keystone or niche player.	No
[52]	Not provoking unnecessary competition between developers in a SECO improves ecosystem health. Follows [7] in a view of ecosystem health.	No
[53]	Argues that health of a marketplace is related to health of a SECO. A marketplace is seen healthy if ISVs are satisfied.	No
[54]*	Follows [29] in a view of ecosystem health; health is long-term financial well-being and long-term strength of a network. Proposes a set of metrics to evaluate ecosystem health of Platform-as-a-Service Providers. Metrics include, e.g., a number of active developers in a given time and a number of unique programming languages used.	Yes

*An article's main focus is in the concept of 'ecosystem health'

From the set of 38 papers, nine are journal and 29 are conference articles. Despite several search engines used in this study, a rather small set of publication forums are present in the final dataset. The most often used conference series are International Conference on Software Business (ICSOB, 8 articles), Management of Emergent Digital EcoSystems (MEDES, 6), European Conference on Software Architecture and its workshops (ECSA and ECSAW, 5). *Journal of Systems and Software* (4) and *Information and Software Technology* (4) have published the majority of the journal articles in the dataset.

The papers included into the dataset are written by 75 authors; however, *Slinger Jansen* (Utrecht University) has an authorship in 14 articles out of 38. Other active authors in the field of software ecosystem health are *Konstantinos Manikas* (5 articles, University of Copenhagen), *Sjaak Brinkkemper* (4, Utrecht University), *Klaus Marius Hansen* (4, University of Copenhagen) as well as *Cláudia Werner* and *Rodrigo dos Santos* (4, University of Rio de Janeiro). This shows that the field is heavily addressed by a small set of academicians.

Figure 2 illustrates the publication years of the selected articles. Oldest articles included in this study are published in 2009. The figure, furthermore, reveals

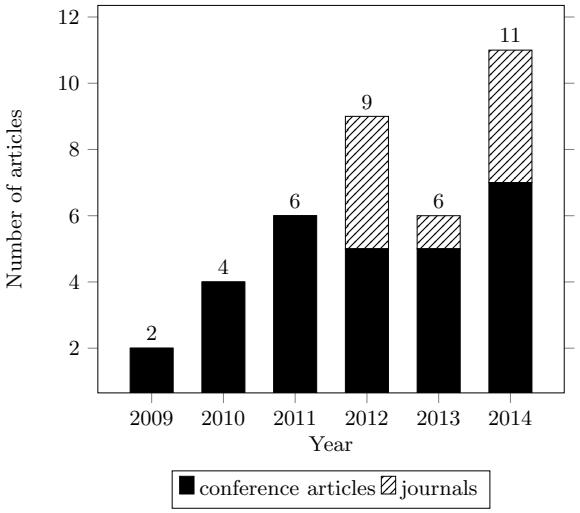

Fig. 2. Number of papers published yearly

that activity in the field of ecosystem health is constantly growing, although the overall volume is still rather small.

The descriptives in Figure 2 yield an answer to RQ1 as it is clear that there is an increasing scholarly interest and dialogue related to software ecosystem health. This dialogue is, as seen from the conference and journal forums, related to the computer science discipline with some interdisciplinarity with business and management sciences. The discussion is based on a relatively narrow pool of authors within a narrow disciplinary setting.

Beyond the descriptive, the definitions of ecosystems are sparse. Even though the works often cite similar origins, namely Iansiti & Levien [7,8], the different works use the term 'ecosystem health' very differently. This is apparent in Table 1 where the views on 'ecosystem health' vary significantly. Where some focus on explaining ecosystem health through the diversity of actors, some look at multiple factors, such as the "biology" of the ecosystem, as a source of explanation. These differences come from the research question and the narrative of the studies which seldom focus significantly on the actual theoretical framework of ecosystem health and rather use this elusive definition to move quickly to the research question at hand. This to an extent, makes the author to pick appropriate portions of a few seminal works when making their case. Answering to RQ2, there is little support to a consensus definition of 'ecosystem health'.

Finding no support for RQ2, we look for characteristics of ecosystem health. Drawing from Table 1 factors, actors or agents that relate to 'ecosystem health' are the *internal structure of the actors* (e.g. diversity, composition and evolution), *external influences* (e.g. stakeholders, entry barrier, openness), *internal forces* (e.g. community development, feedback, joined vision) and *outputs* (e.g. productivity, value created by actors and growth). This synthesis is illustrated in Figure 3. Much of the literature emphasize the role of orchestrator and keystone

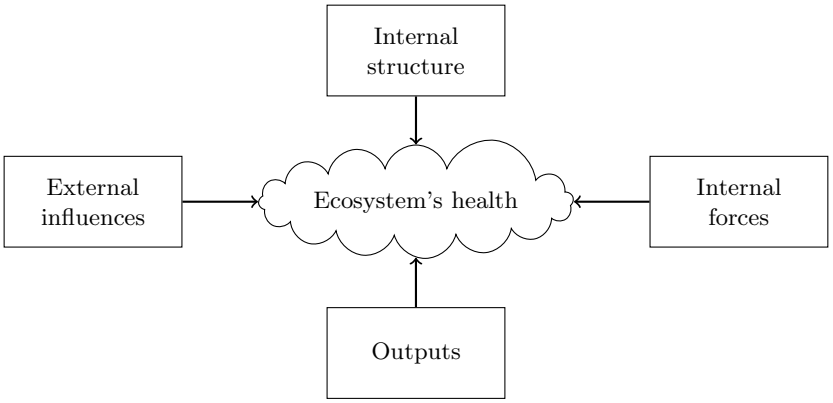

Fig. 3. Factors affecting to health of an ecosystem

actors to moderate the above mentioned factors. Answering to RQ3, there are common characteristics but these are differently referred in literature. Arguable, this is due to the absence of share theoretical frame.

Finally, finding a number of characteristics for ecosystem health, our focus turns towards empirical evidence. From the 38 studies, only a selected few focus on producing empirical evidence. From these, only one makes a strong effort to validate a theoretical frame. Furthermore, often studies propose to use of simple metrics such as a number of commits or a number of lines of code (LOC) as a measure of health (productivity). While these certainly measure some activity in an ecosystem, it is not clear how useful these are as indicators of productivity [55]. We find no or limited support for RQ4.

To summarize, our study contributes to the field of software ecosystem health by showing that there, indeed, is increasing scholarly interested towards the concept (RQ1). However, as shown in Table 1 and above analysis, there is no shared understanding on what does the concept mean (RQ2). This misunderstanding has, as discussed more in the following section, and will cause problems in the studies of ecosystem health. However, we were able to identify the common elements used and synthesize them (RQ3). It should be, however, noted that these elements differs a lot from presented two frameworks of business [7,8] and software ecosystem health [10]. Finally, we showed that despite increased interest, there is a lack of empirical studies addressing existing or extincted software ecosystem health (RQ4).

5 Discussion

Currently, there seems not to be a coherent view of what is 'software ecosystem' and several concepts are often used interchangeably to depict either the same or different objects. For example, concepts such as 'ecosystem', 'network', 'community'

and 'platform' are used to depict the same phenomenon[1]. Our view of a business ecosystem—and thus, its special case, 'software ecosystem'—follows the original work by Moore [1] and sees an ecosystem as an economic community. Thus, we question does loose communities of individual developers or software firms form an ecosystem. Therefore, the scientific community would benefits from established use of the terms.

This SLR demonstrates that there is much work to do. It seems that the definition of health in the ecosystem is rather tautological; the definitions of healthy ecosystem are derived from healthy firms. A healthy firm is rarely defined, except Jansen [27] who define healthiness by willingness to grow and longevity.

We would like to raise the question on philosophical (as well as strategic) question what does a business ecosystem actually stand for. Its analogies to biological counterparts are often loosely referred to, however the actually and exact conceptual work seems to be missing here. The seminal work by Richard Dawkins, *Selfish Gene* [56], proposed how an organism is expected to maximise its inclusive fitness, the number of copies of its genes pass on globally. A firm does not have such ultimate goal but its goals are defined locally by the owner and even the survival of a particular firm is not necessary, since a firm is a tool that serves certain purpose that its owners have defined. Therefore, we should thoroughly consider the conceptual foundations of business ecosystem and deriving on this conceptual work, consider carefully again what does *healthiness* mean in this SECO context.

For instance, firstly, it is not much considered why business ecosystems do exist and under what circumstances a company should participate in the particular ecosystem [57]. Business ecosystems are considered to lead to competitive advantages for each of the partners in the business ecosystem [58]. Thus, the question remains, what are these competitive advantages and their characteristics to consider when joining to an ecosystem. Secondly, business ecosystems may provide firms resources and information "to navigate in a constantly changing competitive environment" [59]. Thus, what are such mechanisms that a firm should use to evaluate the access and availability of above "resources and information". Thirdly, it has been considered that an ecosystem should be responsible for its participants: "SECO platform ownership also brings responsibilities" [50]. This question is not clear even network literature and practice — when a network's focal company faces financial problems, its loyalty towards its suppliers has been deteriorating in many cases. In similar manner, large amount of business ecosystem literature includes rather positive expectations how firms may (or they should) behave towards their ecosystem partners.

The above ideas lead us to suggest the following questions for further research:

1. What are the philosophical foundations for business ecosystems, especially when considering the decisions to join or detach a firm to/from a business ecosystem?

[1] J. West (2014) "Networks, Communities, Ecosystems and Platforms". http://blog.openinnovation.net/2014/08/networks-communities-ecosystems-and.html Accessed March 24, 2015.

2. What characteristics to use for evaluating the 'healthiness' a business ecosystem? Can we define such 'early warnings' that may give a signal about "sickness of a business ecosystem"?
3. What kinds of strategic patterns do different types of business ecosystems form? For instance, further development of work by Zahra & Nambisan [59] linked with above questions may be helpful.

To summarize, we question what does, and what should, the concept 'ecosystem health' stand for. Furthermore, the different viewpoints on the ecosystem blur the overall picture even more. For example, Apple's App Store (iOS) software ecosystem can be argued to be a healthy one (for its orchestrator) due to the large numbers of application developers, customers and revenue generated. Furthermore, it has been able to absorb external shocks caused by competitors. However, the ecosystem is not 'healthy' for the majority of existing or newcomer application developers. In contrast, the ecosystem might be 'healthy' for customers (a plethora of cheap offering) and superstars (e.g., Supercell Oy and King Limited have been able to create a stable revenue flow through the ecosystem). Thus, we call for theoretical development, supported with strong empirical evidence, on the concept of 'ecosystem health' to normalize the discussion. This would help future endeavours on developing metrics and measures, early warning signal systems and government levers for software ecosystem health.

6 Limitations and Conclusions

Naturally, this study has limitations. First, we limited the data gathering only on electronic searches on article databases. This might cause a lack of articles not indexed on these databases. In a further study, a manual search of selected publication forums should be performed. Second, we focused only on SECOs' health, due to the nature of the audience. Thus, an inclusion of health of digital, mobile and business ecosystem would broaden the picture of the whole 'ecosystem health' concept.

However, this study showed that the number of articles discussing on the concept 'software ecosystem health' is constantly growing. Although the studies are often based on the seminal work by Iansiti & Levien, we could not find a consensus for what software ecosystem health stands for. The term has been used to describe, e.g., financial well-being of individual actors, performance and longevity of the whole ecosystem. Furthermore, the number of empirical studies remains low. Thus, we call for further work for defining the philosophical standpoint for business and software ecosystem as well as their healthiness.

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