The Effect of Generic Strategies on Software Ecosystem Health: The Case of Cryptocurrency Ecosystems

Susanne Boshuis
Utrecht University
Utrecht, The Netherlands

Tim B. Braam
Utrecht University
Utrecht, The Netherlands

Alejandra Pedroza Marchena
Utrecht University
Utrecht, The Netherlands

Slinger Jansen
Utrecht University
Utrecht, The Netherlands
slinger.jansen@uu.nl

ABSTRACT

Thus far, no research has been done into the effect of business strategies on software ecosystem health. This research aims to fill that gap by combining the Open Source Ecosystem Health Operationalization (OSEHO) and generic strategies. These models are combined and tested on five cases of cryptocurrency ecosystems: Ripple, Ethereum, Litecoin, IOTA and zCash. Findings suggest that the generic strategy Focused Differentiation has the biggest positive impact on ecosystem health. Further research is necessary to see if this is also true for more mature and more stable ecosystems.

CCS CONCEPTS

• **Social and professional topics → Project and people management**; • **Software and its engineering → Software system structures**;

KEYWORDS

Software Ecosystems Health, Cryptocurrencies, Business Strategies

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1 INTRODUCTION

Over the last few years, the body of literature on software ecosystems has grown vastly [13]. As can be derived from the name, software ecosystems more or less find their existence in the analogy with natural ecosystems. For example, both have participants that are both collaborating and competing with one another over finite resources which can cause participants to be included or excluded from the ecosystem. However, there are also differences to be mentioned: in a software ecosystem, a participant can decide for themselves to enter, exit or even destroy the ecosystem, whereas in a natural ecosystem the participants are involuntarily part of the ecosystem [11].

Multiple authors have proposed definitions for software ecosystems. In these attempts, three concepts (actors, software and networks) seem to stand out which have been combined by Jansen et al. into the following definition: *A software ecosystem is a set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them* [12].

To continue with the biological analogy of software ecosystems, three key concepts have been introduced by Iansiti and Levien [8]. In their paper, they compare business and natural ecosystems in which they point out that the ecological literature indicates that it is important in natural systems to show the ability to support a diversity of species. In a similar way, it is also significant that business ecosystems are able to exhibit diversity [8]. Within the context of business ecosystems, they call this principle of variety "niche creation". In software ecosystems, the capacity to create meaningful diversity is reflected in the growth of the number of software developments. Additionally, Iansiti and Levien introduce the two concepts "robustness" and "productivity" to accompany "niche creation" [8]. In this context, robustness refers to the capability of an ecosystem to face and survive disruptions, whereas productivity is related to the efficiency with which an ecosystem converts inputs into outputs [8]. Together, these three concepts pose an indication of the ecosystem's health.

However, in the context of businesses, existing research has not yet focused on the implications of variation on the ecosystem's health in terms of keystone organization's business activities or strategies. Keystone organizations are basicly the hub of a network, and as such should act beyond their own boundaries [7].

As has been mentioned, actors in a software ecosystem share a specific market on which they compete and collaborate. Nonetheless, these actors all want to have some sort of differentiating property that will give them some extent of competitive advantage over the others, which is often gained through implementing certain strategies [17]. This paper aims to fill that gap by answering the following research question:

"How do keystone organization's generic strategies of software ecosystems affect the ecosystem's health?"

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The next section of this paper will further discuss existing literature on the subjects of software ecosystem health and business practices. Thereafter, the chosen model is operationalized, the cases are introduced and data collection and analysis will be thoroughly discussed. Before drawing conclusions and discussing the limitations of the research, the results of the case study will be described.

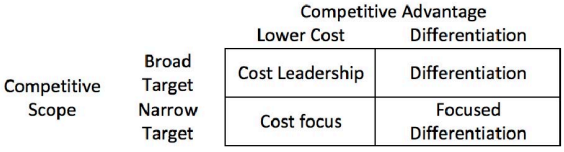

Figure 1: Generic Strategies [17]

2 LITERATURE STUDY

2.1 Software Ecosystem Health

As with natural and business ecosystems, the health of a software ecosystem indicates the system's likeness to reach longevity and propensity for growth [3]. To assess the quality of an software ecosystem, Bedoya et al. were the first to create a general model to assess this: the QueSO model [5]. Part of the quality of a software ecosystem is its health, which means that a better health leads to an overall better quality of the software ecosystem. In their paper they propose some metrics for different pillars and their characteristics. However, since their model is so broad, this research requires a model that is more specific for ecosystem health. To this end, Jansen proposed a model with several metrics: The Open Source Ecosystem Health Operationalization, or OSEHO for short [10].

The model consists of three layers (Theory Level, Network Level, and Project Level) and three pillars (Productivity, Robustness, and Niche Creation). The three levels indicate how the model has been constructed: the theory level are the guidelines as proposed by Den Hartigh et al. for operationalizing ecosystem health [3]. In the network level, the open source characteristic is introduced and the project level introduces the project health metrics. The three pillars are equal to the earlier discussed key concepts of ecosystem health as introduced by Iansiti and Levien [8].

As the name indicates, the model is meant to be used for assessing the ecosystem health in the case of open source projects. A project is open source when its source code is made publicly available by the copyright holder and anyone can study, change and distribute the project for any purpose [14].

2.2 Generic Strategies

As has been mentioned, firms always search for competitive advantage in their market. Through their competitive strategy, firms try to adapt to a strategy that is not only profitable and sustainable but also one that is different from the rest [17]. According to Porter, there are two types of competitive advantage: (1) Lower Cost, and (2) Differentiation. Firms have either one of those two types of advantages which they achieve through focusing on different aspects of their operational management (i.e. through performing business activities). A firm is pursuing Lower Cost competitive advantage when they have the ability to offer a product that is cheaper (i.e. more efficiently designed, produced and marketed) than its competitors. Alternatively, Differentiation is pursued when a firm offers a product that has unique and superior value for the customer. This value could relate to quality, special features, or after–sale services.

Additionally, Porter indicates the importance of competitive scope in the industry. All industries have variations in products, distribution channels and customers and therefore choosing a different scope as a firm can give some extent of competitive advantage over competitors [17].

The two notions of competitive advantage and competitive scope have been combined into a model on generic strategies, as displayed in Figure 1. These strategies make it clear that there is no one type of strategy that is appropriate. It is important to note that competitive advantage is central in all generic strategies and that the worst strategic error is to be stuck in the middle or to pursue multiple strategies, since this is analogous with not achieving any strategy because of their contradictions and therefore leads to below–average performance [17].

The four generic strategies all have their specific characteristics. Cost Leadership is focused on achieving the lowest cost on the market for a broad public (large group of customer types), whereas Cost Focus is about achieving the lowest costs in a niche market. Differentiation is a strategy in which the focus lies on offering a product with higher quality and/or special features for the general public, whereas Focused Differentiation is focused on offering a product tailored to a specific niche market. These definitions of different generic strategies give a concise image of what kind of activities are performed. This is not only useful in identifying the difference between firms but, when turned around, the business activities can also be summarized into a generic strategy, which illustrates the reason why this model is used to assess the case studies that were chosen for this research.

3 METHODS

3.1 Research Goal and Research Questions

The goal of this research is to identify what effect strategies have on ecosystem health. In order to fulfill this goal, this paper integrates theories on generic strategies and software ecosystem health. This paper will therefore answer the following main research question: "How do keystone's generic strategies of software ecosystems affect the ecosystem's health?" In order to do so, the research question is divided into three sub questions:

(1) What are the business activities of the ecosystem and to what generic strategies do these activities translate?
(2) What is the ecosystem's health?
(3) What metrics in the OSEHO of the ecosystem are affected by their generic strategies?

These three questions all answer a different sub component of the main research questions which is why they are relevant. The different components include (1) the current business activities, (2) the current ecosystem's health, and (3) the measured effect of the business activities on the ecosystem's health.

3.2 Case Selection

Cryptocurrencies are different from national currencies because they are virtual, decentralized, and protected by cryptography [6, 19]. They are virtual because they are a digital representation of value, medium of exchange and unit of account. They are decentralized because they do not have a central administrative authority. Furthermore, cryptocurrencies must be cryptographically signed each time they are transferred and their mathematical base relies on the network of participants who run special software to solve complex algorithms used to validate the transactions [4]. The choice for cryptocurrencies as a case study for this research is based on personal interest, the novelty of the subject and relatively small coverage in terms of scientific, software-related research.

For the cryptocurrency ecosystem, it is easy to identify the diversity of species mentioned earlier: At this time there are over 1300 cryptocurrencies[1]. Bitcoin was the first virtual currency: it appeared in 2009 after Satoshi Nakamoto published a document which explained the Blockchain technology in 2008 [15]. Cryptocurrencies have emerged based on Blockchain technology, each currency with their own specific characteristics that distinguishes them from the rest. It is expected that the many cryptocurrencies will co–exist rather than one cryptocurrency taking over others [9].

This research will focus on the business activities and the health of the cryptocurrency ecosystem and as has been mentioned, the OSEHO is focused on open source projects. Therefore, the cases that are selected need to be open source projects. Additionally, the scope of the research needs to be made clear, since in assessing ecosystem health one can take different views: larger (super) or smaller (sub) ecosystems. This research will focus on specific cryptocurrencies within the general cryptocurrency ecosystem, and will therefore view each of the selected cryptocurrencies as an ecosystem of their own.

Not all cryptocurrencies are open source. Therefore, a selection of five cryptocurrencies is made which are all open source projects and thus suitable to be studied using the OSEHO. The non-probability sample for this research includes the cryptocurrencies Ripple, Ethereum, Litecoin, IOTA and zCash. These five have not only been selected due to their open source characteristic but also because they are all independent from each other and all are in the top 25 of cryptocurrencies given their market cap[1]. Additionally, all these cryptocurrencies have an identified and structured group of people or a company backing them.

The independence of the cryptocurrencies is important since it firstly indicates that the cryptocurrencies do not influence each other's business activities and secondly that they are different at at least a minor level. Additionally, the placement in the top 25 market cap is relevant since it guarantees that the currency is relatively established, which offers a few advantages to the study. It leads to more and better accessible data and documentation. Additionally, the difference between these currencies is relatively big, making for a more interesting comparison.

Important to add is that Bitcoin, despite being independent from the others and placed in the top 25 market cap, is not selected as a case study in this research. Reasons for this include its age, reputation and market leadership, since these factors could greatly influence the results of the case comparisons. Additionally, Bitcoin is one of the cryptocurrencies that is not backed by an organization of people or company which means that there is no reliable way of identifying a generic strategy.

[1] www.coinmarketcap.com, as of 23–11–2017

3.3 Data Collection

Generic Strategies. Data for this metric is collected through the official websites and forums[2] of the different cryptocurrencies. To improve the reliability of this data and the validity of this research, the data is crosschecked using the cryptocurrencies' white papers [1, 2, 15, 16, 18].

The business activities that are found in this way are put in a short overview which in turn is used to classify the cryptocurrencies into one of the four generic strategies as stated by Porter [17].

The OSEHO. The OSEHO as proposed by Jansen is a generic model and therefore has to be adapted to fit this research. First of all, this research only takes the Project Level of the OSEHO into account since it can be used as an aggregate measure for ecosystem health [10]. Second, not all metrics are applicable to all kinds of projects and not all data for each of the metrics is publicly available. Therefore, the model has to be slightly adapted to fit the cases of the cryptocurrencies, both by removing and adding some metrics.

The metrics New Tickets, Bug Fix Time, New Downloads and Mailing List Responsiveness from the productivity pillar, have been discarded considering the case studies, since they are not applicable. The first two metrics are indicators of how quickly problems are resolved and, in the case of cryptocurrencies, the community is in large responsible for these fixes and fixes are made continuously. However, both Ripple and Ethereum have a bug report bounty website that rewards people for reporting bugs[3]. Unfortunately, data from these websites is not publicly available. For this reason, these two metrics are not included, as data collected from the GitHub repositories could be skewed. The latter two metrics are not part of the business activities of cryptocurrencies and hence are not applicable for this study.

The same is true for the metrics User Loyalty, Multi-Homers, Organizational Maturity and Switching Costs from the robustness pillar. Since cryptocurrencies more or less function as investments, users can freely buy or discard coins and are not bound to one specific currency. This also applies to the metric Switching Costs. Furthermore, since cryptocurrencies do not use different economic platforms, multi-homing is not an applicable metric. Also, Organizational Maturity is not measured since all cryptocurrencies are relatively young and therefore this metric will not provide additional insights.

The metrics Supported in Natural Languages, Variety in Supported Technologies, Variety in Development Technologies and Multiple Markets from the Niche Creation pillar are not applicable to cryptocurrencies for various reasons.

Last, the metrics KLOC/time period added (productivity pillar), Contributor Satisfaction, Contributor Ratings and Reputation, User Satisfaction, Artifact Quality, Contributor Connectedness (robustness pillar) and Variation in Contributor Type (niche creation pillar) have been discarded due to the unavailability of data.

[2] Community forums on official websites and endorsed subreddits on www.reddit.com
[3] https://bounty.ethereum.org/ and https://ripple.com/bug-bounty/

Table 1: Selected metrics, their descriptions and their data sources

Metric	Description	Data Source
Productivity		
Knowledge and Artifact Creation	The number of manuals and other artifacts, created by contributors	Github, Official Websites, Coinmarketcap[a]
Spin-offs	A spin-off is defined as a new coin that is based on the coin under investigation	Official websites, forums[b], CoinDesk[c], StackExchange[d]
Forks	A fork is defined as a protocol update	Official websites, forums[b], CoinDesk[c], StackExchange[d]
New Partnerships*	The total number of partnerships that a crypto–currency has	Official websites, forums[b], CoinDesk[c], Lexis Nexis
New Patents*	The number of patents that the cryptocurrency owns	Espacenet
Usage*	The total value of the cryptocurrency that is traded per 24h on average over the last 30 days	Coinmarketcap[a]
Robustness		
Partnerships and Embeddedness*	The number of partnerships that the partners of the cryptocurrency have with each other	Official websites, forums[b], CoinDesk[c], Lexis Nexis
Commercial Patronage*	The support a cryptocurrency receives from other companies	Official websites, forums[b], CoinDesk[c], Lexis Nexis
Capital Contributions and Donations*	The amount of money that a cryptocurrency has received other than investments in the currency	Official websites, forums[b], CoinDesk[c]
Active contributors	The number of people that have made a contribution to the source code since the second half of 2016 and that have over 50 commits since the creation of the cryptocurrency	Github
Interest: Page Views	The amount of page views of the official website(s)	SiteWorthTraffic[e]
Interest: Search Statistics	How often a Google search is performed	Google Trends
Market Share	The percentage market cap for the currency under investigation of the total market cap of cryptocurrencies	Coinmarketcap[a]
Change in Marketcap	The percentage of change in marketcap for the cryptocurrency since June 2017	Coinmarketcap[a]
Niche Creation		
Variation in Project Applications*	The number of ways a cryptocurrency is applied in society	Official websites, forums[b], CoinDesk[c]

* These metrics have not been validated before

[a] www.coinmarketcap.com
[b] Community forums on official websites and official subreddits on www.reddit.com
[c] www.coindesk.com
[d] www.stackexchange.com
[e] www.siteworthtraffic.com

A metric that has been added is the change in market cap. This metric is added in the robustness pillar and gives additional information about the performance of the cryptocurrency. When analysed in combination with the market share, it indicates whether a cryptocurrency is gaining or losing market share and/or value. It is measured as a percentage change since June 2017.

Table 1 shows which metrics have been selected for this research and where data for these metrics is collected. The metrics that are followed by a small asterisk are metrics that have not yet been validated and therefore add some relevance to this research. In this table the metric "Forks" includes both soft forks and hard forks of the cryptocurrency (updates of the blockchain protocol). In this context, a soft fork means that the new version of the blockchain is backwards compatible, whereas hard forks are not backwards compatible. Both types of forks are considered to be good for the health of the cryptocurrency ecosystem and thus will be grouped collectively into this metric.

3.4 Data Analysis

Generic Strategies. Using the official websites and forums of the cryptocurrencies, different business activities are identified. These business activities are then generalized so that a matrix-type table can be made in which Xs can be placed to indicate whether a cryptocurrency performs that activity.

These activities can be judged on factors such as whether they provide additional features, lower costs or better performance. Depending on the outcome of that analysis, the cryptocurrencies can be placed in one of the four generic strategies as identified by Porter [17].

The OSEHO. The results for analyzing the ecosystem's health are presented in a table. To illustrate the health of the ecosystem a ranking method is used. For all metrics in the OSEHO a higher number or amount indicates a more positive effect on the ecosystem's health. Since higher is better, the best performing currency the first rank on this metric, second best gets the second place, and so on. In the end, this is summed up for each of the cryptocurrencies to obtain a final 'score', where the lowest total score indicates the best health. However, it should be noted that the health is measured with respect to other ecosystems and is therefore not an absolute measure of health. This means that healthier does not necessarily equal healthy and unhealthier does not necessarily equal unhealthy. Metrics that include NAs have not been included in calculating the total score, since this can skew the results.

4 RESULTS

4.1 Generic Strategies

Ripple (XRP)[4]. Ripple is a centralized, rather than decentralized, cryptocurrency. However, Ripple is working on becoming increasingly decentralized since 2012 and their process is well underway [5]. For this reason, as well as previously discussed reasons, Ripple is chosen as a case for this research. Ripple uses validator nodes to validate the transactions on their own ledger. Only if 80% of these nodes have validated the transaction is it written in that ledger. Ripple's ledger, XRP ledger, lists all accounts and its latest balances. Additionally, Ripple offers a high transaction speed: A transaction on the Ripple ledger takes 5 seconds on average to be completed with a capacity of 50,000 transactions per second. What also differentiates Ripple is that all 1 billion Ripple coins are pre–mined and therefore the coin is not mine-able. Furthermore, Ripple offers improved security where a secret key is used to access funds. The Ripple wallet also protects the contacts list of the ledger. The transactions on the Ripple network cannot be traced back to any identifiable information and the company Ripple also does not have access to any customer information. Finally, Ripple's transaction fees are relatively low.

Ethereum (ETH)[6]. Aside from the normal financial transactions, Ethereum offers an additional feature: The transaction of smart contracts. The validation of these transactions happens through the network. Ethereum uses a blockchain: each time that a new block is mined, it is added to the blockchain with the latest transactions processed by the network. The transaction time of Ethereum is relatively high: it takes about 15 seconds for a transaction to be processed and they have a capacity of 15 transactions per second. Additionally to the regular mining of the maximum number of 60 million coins, miners can get a reward of 3 ETH (approx. $3200[1]). In the basis, Ethereum's security protocol is that Ethereum offers an extra protection against hacking because each computer that is part of the Ethereum network has a copy of the ledger stored on it. Only the owner of a document can access it by using their own private key. Ethereum also has a fairly high transaction fee.

Litecoin (LTC)[7]. Litecoin can handle a relatively higher transaction volume and has a transaction speed of around 2.5 minutes with a capacity of 28 transactions per second. Additionally, Litecoin offers a reward for miners where miners are awarded with 25 new Litecoins (approx. $5000[1]) per block that is mined. In total, there is a maximum of 84 million Litecoins available. Additionally, the amount in a Litecoin transaction is obfuscated to guarantee its confidentiality. Litecoin has a medium transaction fee compared to others.

IOTA (MIOTA)[8]. With IOTA, each transaction is signed with a private key and each transaction verifies two other random transactions. One large differentiating aspect of IOTA is that IOTA does not use a Blockchain technology for their transactions but rather uses a DAG: A tangle where each transaction forms a new block and two previous transactions must be approved. Another notable difference is its transaction time: IOTA has a transaction time of 10 or less seconds for a transaction to be processed and a capacity of 500-800 transactions per second. Like with Ripple, all approximately 2,8 trillion MIOTA are already created with IOTA's genesis block. For the security of its transactions, IOTA uses a multi-sign signature on its addresses in an off-line environment. Addresses in the IOTA DAG are obtainable through the use of a private key. However, all private keys are generated through a seeds key index and can only be used once. Apart from being used as a digital currency, IOTA also offers the possibility to process payments between devices connected to the Internet of Things. A very notable thing about IOTA is their non–existent transaction fee.

zCash (ZEC)[9]. The largest differentiating aspect advertised by zCash is its additional privacy. zCash main focus point is on privacy which is ensured by using a technology called zk-SNARKS: an advanced cryptographic technique called zero-knowledge proofs. They use it to guarantee the validity of transactions without revealing any additional and/or identifying information. This zero-knowledge proof is also used to ensure the security in zCash's own ledger. zCash is mine-able, with a maximum amount of 21 million ZEC. Its transaction time is 2,5 minutes with a capacity of 26 transactions per second. Last, zCash has a medium transaction fee.

Table 2 shows an overview of the different business activities that have been identified through the information that has been described above. Based on these results, the cryptocurrencies are classified into one of the generic strategies that reflects their activities best. These results are shown in Figure 2. First, Ripple is classified into Cost Leadership since it offers its services to a broad public: Anyone is able to use it for any payment. However, they also offer low transaction fees and low transaction times compared

[4] www.forum.ripple.com, www.ripple.com
[5] https://ripple.com/insights/how-we-are-further-decentralizing-the-ripple-consensus-ledger-rcl-to-bolster-robustness-for-enterprise-use/; https://ripple.com/dev-blog/decentralization-strategy-update/
[6] www.ethereum.org, www.blog.ethereum.org
[7] www.litecoin.com, www.litecoin.org
[8] www.blog.iota.org, www.iota.readme.io, www.iotasupport.com
[9] www.z.cash/blog, www.z.cash

Table 2: Business Activities for the Cryptocurrencies

Activities	XRP	ETH	LTC	IOTA	ZEC
Blockchain	X	X	X		X
Transaction Speed	+++	+++	++	+++	++
Transaction Cost	+	+++	++	+	++
Nr. of Transactions/s	+++	++	++	+++	++
Coin is mine-able		X	X		X
Miners Reward		X	X		
Maximum Nr. of Coins	+++	++	++	+++	++
Public Dig. Sign.		X			
Sec. Keys/Off-line Env.	X		X	X	X
User Info. Obtainable		X		X	
User Info. Unknown	X		X		X
Adv. Privacy Cryptog.		X*			X
Additional Feature(s)		X		X	X

* Ethereum has a partnership with zCash on the use of zk-SNARKS but the implementation is not finished yet.

to the industry standard. Second, Litecoin is classified into the same quadrant as Ripple since it was created with the purpose of offering the service of payments to a general public. Its improvement was to achieve more transactions in less time and lower transaction fees.

Cost Leadership	Differentiation
Ripple Litecoin	zCash
Cost Focus	**Focused Differentiation**
	IOTA Ethereum

Figure 2: Cryptocurrencies classified into their generic strategies

Ethereum uses the classic blockchain technology and other activities associated with the first wave of cryptocurrencies but with lower costs and in less time. However, the transaction costs are still much higher when compared to the other cryptocurrencies. Additionally, the ethers (Ethereum's currency) are aimed to a specific market of developers and users of smart contracts. Therefore, it is classified into Focused Differentiation. Also in Focused Differentiation is IOTA. IOTA offers a significantly different product since it does not use a blockchain. Furthermore, IOTA also focuses on a market that is oriented towards the Internet of Things and therefore has a narrowed focus. Last, zCash is classified into Differentiation, due to its implementation of a strong security protocol, that makes it different from the rest. However, an interesting observation is that, although they have not specifically adapted their strategies towards this goal, they do serve a niche market[10].

So, to answer the first research question, by studying the official websites behind the cryptocurrencies, eighteen different business activities were identified that are specific for cryptocurrencies. These activities included used technologies, technological properties and focus points of the cryptocurrencies. Using these business activities, the cryptocurrencies could be assigned to the generic strategies as defined by Porter [17].

However, it should be noted that it is hard to classify the cryptocurrencies into only four generic strategies due to their large overlaps and differences. Therefore, the pillars of the crytocurrencies played a decisive role in classifying them. For that reason, activities that pointed towards a cost leadership strategy include low transaction costs and high transaction speeds. These activities on their own could also point towards Cost Focus but Ripple and Litecoin both do not specifically address a niche market, which takes priority in a cost focus strategy. There was no cryptocurrency that matched this strategy.

Additionally, an activity pointing towards a focused differentiation strategy is additional features. However, it is important to see here what kind of additional features are offered: the features should point towards addressing a niche market. This is the case for Ethereum and IOTA which address a market that is interested in either smart contracts or the internet of things. zCash offers an additional feature in the form of extra privacy. zCash does this not to specifically address a specific niche market and therefore, zCash is assigned to differentiation. The overlapping activities for these two strategies include higher costs and a lower number of transactions per second.

4.2 Ecosystem Health

Table 3 shows the results of the ecosystem health assessment. In this, it can be observed that Ethereum has the healthiest ecosystem of the cases studied. Ripple is a close second, followed by Iota, Litecoin and zCash. This could be interpreted as that Ethereum has the best chance at sustained longevity and propensity for growth of the ecosystems studied. Ethereum is performing better on Knowledge and Artifact Creation and market share compared to the other cases, despite not being the oldest in this study. This is not entirely surprising: Ethereum is the second most valuable cryptocurrency at this moment[1].

What is surprising, in a way, is that Litecoin scores badly compared to the other cryptocurrencies. Litecoin is the oldest cryptocurrency under investigation in this research and has a large number of active contributors. Despite this, Litecoin has a small market share and a lesser health compared to the other cryptocurrencies. However, it should be noted that some of the metrics that were initially measured have been left out to score the ecosystems' health due to the unavailability of some of the data.

By applying the OSEHO by Jansen, the second research question can be answered [10]. Based on the collected data, the cryptocurrency ecosystem's were ranked. From this ranking it appears that Ethereum has the best ecosystem health, followed by Ripple, Iota, Litecoin and zCash in that specific order. This means that, based on these results, Ethereum's ecosystem has the best chance at sustained longevity and the propensity for growth when compared to the other ecosystems. In this, it should be mentioned that this research speaks of a better or worse ecosystem health compared to the other cases under investigation, rather than a health or unhealthy ecosystem in general.

[10]https://forum.z.cash/t/zcash-market-prospectus-2016-2017/8328

Table 3: The values for each of the metrics for all six cryptocurrencies

Metrics	Ripple	Ethereum	Litecoin	Iota	zCash
Knowledge and Artifact Creation	83	216	187	48	46
Spin-offs	0	0	0	0	0
Forks	0	5	0	0	0
New Partnerships	5	2	1	27	2
New Patents	1	0	0	0	0
Usage	$3.996.079.000	$4.936.959.667	$1.397.126.533	$258.814.987	$209.383.003
Partnerships and Embeddedness	0/5	0/2	0/1	2/27	0/2
Commercial Patronage	10	3	0	5	1
Capital Contributions and Donations	0	NA	$520,096.85	$497,730,000	$1,000,000.00
Active Contributors	8	9	17	2	6
Interest: Page Views	124,636,185	37,071,955	9,286,695	1,390,285	NA
Interest: Search Statistics	11.43	11.25	5.09	3.58	0.87
Market Share	9.46%	17.55%	1.91%	1.41%	0.28%
Change in Marketcap	−3.2%	−6.05%	0.2%	1.4%	NA
Variation in Project Applications	1	2	1	2	2
Score	**34**	**30**	**46**	**41**	**52**

Table 4: Integration of the generic strategies and OSEHO

	CL	CF	D	FD
Knowledge and Artifact Creation	+		– –	+
Spin-offs	X		X	X
Forks	– –		– –	X
New Partnerships	+		–	++
New Patents	X		– –	– –
Usage	+		– –	+
Partnerships and Embeddedness	– –		– –	X
Commercial Patronage	X		–	+
Active Contributors	++		–	+
Interest: Search Statistics	++		– –	+
Market Share	+		– –	++
Variation in Project Applications	– –		++	++

4.3 Integration

For the integration of the two models, the metrics that had NAs have, again, been taken out. Each metric has been assigned a value based on the preceding health assessment, this is shown in Table 4. There are five values displayed in this table: a double minus for a very negative effect, a single minus for a negative effect, an X for no visible effect, a single plus for a positive effect and a double plus for a very positive effect. These values reflect the effect that has been found for that specific strategy. This effect can be interpreted as that the cryptocurrencies that have been assigned this generic strategy perform either better or worse on this metric when compared to the cryptocurrencies that have been assigned to another generic strategy. From Table 4 it can be derived that the generic strategies all have different effects on the metrics from the OSEHO framework. No effects of the strategy Cost Focus have been observed since none of the cryptocurrencies that were selected were appointed that strategy.

The large difference between the effects of a differentiation strategy and a focused differentiation strategy is surprising since the only difference is tailoring the product to a niche market. However, this result could be explained by the age of the cryptocurrency that has been assigned the differentiation strategy: zCash is the youngest cryptocurrency under investigation in this study, being only 14 months old at the time of writing. zCash therefore, has not yet had enough opportunities to establish itself in this highly volatile market.

The effect that differentiation and focused differentiation strategies have on variation in project applications is not surprising. They are strategies that focus on doing things differently than regular and providing additional services can be part of these strategies.

To answer the remaining research question, from Table 4 it can be concluded that a focused differentiation strategy has the most positive impact on an ecosystem's health, followed by a cost leadership strategy and a differentiation strategy. It should be noted, however, that only one of the five cryptocurrencies under investigation has been assigned to this strategy. Moreover, this cryptocurrency, zCash, is the youngest one under investigation. This means that the results for this specific strategy cannot and should not be generalized.

5 DISCUSSION

As in any research, this research has its limitations. First of all, the integration of the OSEHO framework and the four Generic Strategies is driven by knowledge gleaned from the literature. The resulting integrated model is based on the findings after inspecting the cryptocurrencies' business activities and health. Replicating the results of the implementation of the integrated model in other cases than cryptocurrencies is necessary to ensure external validity.

As far as the data is concerned, the only resort to collect data was publicly available data and due to the extensive number of metrics it is possible that the data is not fully complete. Additionally, some of the cryptocurrencies are more closed in sharing their data than others which could lead to some incomplete measures.

Furthermore, this research performs a comparative case study on cases that are all part of the same industry. The results of this research are therefore not generalizable and it can be recommended for future research to expand this research into further case studies to check for patterns and relations regarding business activities and ecosystem health. Moreover, a longitudinal study could provide insights into long-term effects, which this study is not able to do since it is based on a single moment in time.

The software ecosystem studied in this research is still quite young. In the short period of time it has been alive it has suffered several transformations which are acceptable in a system that is consolidating but which will consequently impact its health.

The relevance of this study is in the snapshot of the current ecosystems' health that it provides. It could be used as a metric in predictions of future health. Additionally, the side by side comparison of ecosystem health can be informative to anyone who wants to base their actions on the current health of the ecosystems. A more theoretical relevance is in the relationship between the generic strategies and the metrics of the OSEHO as it proves that different strategies have different effects on ecosystem health.

6 CONCLUSIONS

The main goal of this research was to investigate the effect of keystone's generic strategies on the health of software ecosystems. In order to achieve this goal, the following research question was formulated: "How do keystone's generic strategies of software ecosystems affect the ecosystem's health?" In order to guide this research and answer this research question the following sub questions were drawn up:

(1) What are the business activities of the ecosystem and to what generic strategies do these activities translate?
(2) What is the ecosystem's health?
(3) What metrics in the OSEHO of the ecosystem are affected by their generic strategies?

These three subquestions have all been answered in the generic strategies, OSEHO and integration parts of the results section respectively. To summarize and answer the main research question of this research, from the cases under investigation in this research, it appears that focused differentiation and cost leadership have a positive impact on an ecosystem's health, albeit to a different extent.

7 FUTURE RESEARCH

Future research could focus on adapting the OSEHO in order to make it better applicable. The OSEHO is a very general model and as it is now, it is assumed that all metrics in the model have an equal weight which might not be necessarily true and that is a gap that this research has not addressed. Furthermore, it might be promising to create a more specialized ecosystem health model to cater to more unique types of software ecosystems, such as cryptocurrencies.

As far as cryptocurrency research goes, it could prove interesting to change the scope of research. Both zooming in and out on one or more cryptocurrencies respectively, could yield additional results, on cryptocurrencies specifically and maybe on a type of health assessment for cryptocurrencies.

Future studies that may want to follow up on or replicate this research could apply methods to other cryptocurrencies for all generic strategies, more so for the cost focus and differentiation strategies. Additionally, in this case, researcher might benefit from a more thorough data collection, for example through interviews with stakeholders and organizations.

REFERENCES

[1] Sean Bowe, Ariel Gabizon, and Matthew D. Green. 2017. A multi-party protocol for constructing the public parameters of the Pinocchio zk-SNARK. White Paper. (2017). https://github.com/zcash/mpc/blob/master/whitepaper.pdf
[2] Vitalik Buterin. 2013. A Next–Generation Smart Contract and Decentralized Application Platform. White Paper. (2013). https://github.com/ethereum/wiki/wiki/White-Paper
[3] Erik den Hartigh, Michiel Tol, and Wouter Visscher. 2006. The health measurement of a business ecosystem. In *Proceedings of the European Network on Chaos and Complexity Research and Management Practice Meeting*. 1–39.
[4] Financial Action Task Force. 2014. Virtual Currencies Key Definitions and Potential AML/CTF Risks. *Commun. ACM* (2014), 6–9.
[5] Oscar Franco-Bedoya, David Ameller, Dolors Costal, and Xavier Franch. 2014. Queso a quality model for open source software ecosystems. In *Software Engineering and Applications (ICSOFT-EA), 2014 9th International Conference on*. IEEE, 209–221.
[6] Andy Greenberg. 2011. Crypto Currencies. (20 April 2011). https://www.forbes.com/forbes/2011/0509/technology-psilocybin-bitcoins-gavin-andresen-crypto-currency.html#1e5ea59e353e
[7] Marco Iansiti and Roy Levien. 2004. *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability*. Harvard Business School Press.
[8] Marco Iansiti and Roy Levien. 2004. Strategy as ecology. *Harvard Business Review* 82, 3 (2004), 68–81.
[9] Mitsuru Iwamura, Yukinobu Kitamura, and Tsutomu Matsumoto. 2014. Is bitcoin the only cryptocurrency in the town? Economics of cryptocurrency and Friedrich A. Hayek. (2014).
[10] Slinger Jansen. 2014. Measuring the health of open source software ecosystems: Beyond the scope of project health. *Information and Software Technology* 56, 11 (2014), 1508–1519.
[11] Slinger Jansen, Michael A Cusumano, and Sjaak Brinkkemper. 2013. *Software ecosystems: analyzing and managing business networks in the software industry*. Edward Elgar Publishing.
[12] Slinger Jansen, Anthony Finkelstein, and Sjaak Brinkkemper. 2009. Business Network Management as a Survival Strategy: A Tale of Two Software Ecosystems. In *Proceedings of the First International Workshop on Software Ecosystems*. 34–48.
[13] Slinger Jansen, Eko Handoyo, and Carina Alves. 2015. Scientists' Needs in Modelling Software Ecosystems. In *Proceedings of the 2015 European Conference on Software Architecture Workshops*. ACM, 44.
[14] Andrew M St Laurent. 2004. *Understanding open source and free software licensing: guide to navigating licensing issues in existing & new software*. O'Reilly Media, Inc.
[15] Satoshi Nakamoto. 2008. Bitcoin: A peer-to-peer electronic cash system. (2008).
[16] Serguei Popov. 2017. The Tangle. White Paper. (2017). https://iota.org/IOTA_Whitepaper.pdf
[17] Michael E Porter. 1998. *The Competitive Advantage of Nations*. Palgrave Macmillan.
[18] David Schwartz, Noah Youngs, and Arthur Britto. 2014. The Ripple Protocol Consensus Algorithm. White Paper. (2014). https://ripple.com/files/ripple_consensus_whitepaper.pdf
[19] Jesse Yli-Huumo, Deokyoon Ko, Sujin Choi, Sooyong Park, and Kari Smolander. 2016. Where is current research on blockchain technology? – A Systematic Review. *PloS one* 11, 10 (2016).