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Towards a Decentralized Information Systems Success Model

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Abstract

This paper conceptualizes the decentralized information systems success model. Based on theoretical and empirical findings in the realm of Information Systems (IS) and Open Source Software (OSS) acceptance and success research as well as various IS enabled socio-economical trends, we define ten constructs (societal norms, economic boundaries, intention to contribute, intention to use, objective quality, heuristic/perceived quality, level of contribution, level of usage, intellectual net benefit and economic net benefit) as well as their relationships. To enhance the understanding of the proposed constructs and relationships, we give examples of the contribution to and the usage of cryptocurrencies. We contribute to the IS research stream of IS acceptance and success by providing a model that allows for an effective examination of decentralized IS success.

Keywords: Decentralized Information Systems; Success Model; Cryptocurrencies

1. INTRODUCTION

Scholarly works on IS acceptance and success are primarily based on or are gradual modifications of the *Technology Acceptance Model (TAM)* of Davis (1989) and the *IS Success Model* of Delone and McLean (1992). While these seminal contributions enabled a vast array of research endeavors, it is evident that they originate from a period in time that was - at least from an IS perspective - different from today (Castells, 2010; Belk, 2014). We argue that emergent and IS enabled phenomena such as cryptocurrencies are forerunners of a much larger global societal shift towards decentralization. Lines between individuals and organizations as well as the contribution and usage side of IS increasingly start to vanish. Therefore, and from a level of analysis perspective, we argue that a strict distinction of individual, organizational and system level as well as IS success and acceptance hinders the scholarly examination of decentralized IS. Furthermore, we argue that the importance of economic success, which is arguably regarded as the most important measure of success in today's societies, will steadily decline due to an increasing automation and thus increases in productivity. As noted by Belk (2014), "the old wisdom that we are what we own, may need modifying to consider forms of possession and uses that do not involve ownership". We propose that instead of materialistic success, the intellectual success will experience a steady rise. Thus, we assume that IS success is determined by very different underlying economical and social psychological drivers.

We draw on various suggestions of IS scholars on research directions regarding IS acceptance and success and add the reasoning from above to formulate the following research questions: First, are

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current IS acceptance and success models suitable to capture the existing and emerging decentralized nature of IS in both development and usage? Second, if current IS acceptance and success models are not suitable to capture the dimensions and ultimately success of decentralized IS, what could a more suitable model look like?

Drawing on propositions, findings and arguments regarding the aforementioned socio-economic and technical developments and the structure and relationships of popular IS and OSS acceptance models such as the TAM and the DeLone and McLean model, we argue that current models should be upgraded. Therefore, we conceptualize a synthesized Decentralized IS Success Model consisting of ten constructs and various relationships that combines and preserves as much insights from both IS acceptance and success models as possible. Furthermore, it enables researchers to examine both the contribution and the usage side of decentralized IS and disentangles economic and intellectual motives in both the intention and the actual level of contribution to and usage of IS. In addition, the model includes societal and economic boundaries and feedback loops from the two success constructs: intellectual net benefit and economic net benefit. We believe that the model is therefore very suitable to examine the existing and emerging phenomena of decentralized IS such as cryptocurrencies and other blockchain-based systems. We provide various suggestions for the operationalization of the model.

The remaining portion of this paper is structured as follows: first, we give background information on the decentralized consensus systems such as cryptocurrencies. In addition, we provide a synthesis of research regarding IS and OSS success models. Second, we conceptualize the constructs and relationships of the decentralized IS success model based on both established IS/OSS acceptance and success models as well as findings in related work. Finally, we conclude the study and provide directions for future research based on the proposed model.

2. BACKGROUND

2.1. Decentralized Consensus Systems and Collaborative Software Development

Cryptocurrencies such as Bitcoin (Nakamoto, 2008) are one of the purest representatives of decentralized IS. Both the development and usage side is highly decentralized. In case of Bitcoin, the decentralization and democratization of money are in fact two of the primary motivators for both its development and usage.

Today, software development is a deeply social activity (Wiese et al.) that is primarily enabled by online social coding communities such as GitHub, which "have created an entirely new, higher level of organization" (Casalnuovo et al., 2015) that is a direct result of the ever increasing interconnectedness of individuals on a global scale (Pereira Junior et al., 2014). Social coding communities "support numerous teams; they share a common technical platform (for work

activities) and a common social platform (via following, commenting, etc)" (Casalnuovo et al., 2015). We define social coding as distributed software development that is not bound to one specific geographic location or fixed organizational associations and is primarily conducted via the internet. We intentionally excluded the term open source in this definition as it is not necessarily the case that the created source code is open. In our study, we rely on many findings that are based on GitHub data, which "is a codehosting repository based on the Git version control system" (Dabbish et al., 2012), It allows users to "form teams to work on real-world projects, primarily software development" (Bagrow and Klug, 2014). Vasilescu, Filkov and Serebrenik (2015) argue that GitHub's features transformed software development entirely by providing a "very low barrier to entry for newcomers". Lerner and Tirole (2001) were one of the first authors that raised important questions such as why top-programmers write software for free and why corporations allow their talents to participate in these projects.

2.2. Information Systems and Open Source Software Acceptance and Success

The acceptance and success of IS and OSS received a lot of attention from researchers. Figure 1 provides an overview of the yearly citations of selected works in this field since their publication. However, in this section, we show that most of these models can be traced back to the TAM (Davis, 1989) and the IS Success Model (Delone and McLean, 1992).

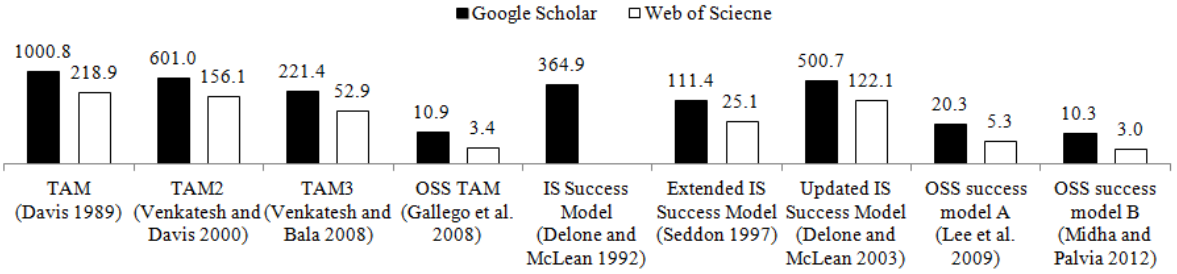

Figure 1 - Yearly citations of important IS and OSS acceptance and success models on Google Scholar and Web of Science since publication. Log-scaled axis. As of Nov. 23rd, 2015.

Table 1 provides a comparison of both popular IS and OSS acceptance and success models. While we oppose the differentiation between IS and OSS acceptance and success models in the context of decentralized IS - as acceptance is necessary for and almost identical with success in decentralized IS - for the sake of clarity, we briefly discuss both research streams separately: First the acceptance and second the success stream.

IS/OSS acceptance research stream TAM, proposed by Davis (1989) is one of the most influential works in the field and receives more than 1,000 yearly citations (see Figure 1). In the model, the authors use five constructs (external variables, perceived usefulness, perceived ease of use, attitude

toward using and behavioral intention) to explain the construct of the actual system use. Venkatesh and Davis (2000) published an extended version of TAM, which they call TAM2. In this model, the diffuse construct "external variables" is refined by two classes of additional constructs: Influence processes (subjective norm, voluntariness and image) as well as cognitive instrumental processes (job relevance, output quality, result demonstrability and perceived ease of use). They show that these two process types significantly influence the acceptance of users. In TAM3, Venkatesh and Bala (2008) create an integrated model based on TAM2 as well findings of Venkatesh (2000) regarding the determinants of the perceived ease of use construct: Anchoring (computer self-efficacy, perceptions of external control, computer anxiety and computer playfulness) and adjustment (perceived enjoyment, objective usability).

Acceptance Models			
TAM 1 (Davis, 1989)	**TAM 2** (Venkatesh and Davis, 2000)	**TAM 3** (Venkatesh and Bala, 2008)	**OSS TAM** (Gallego, Luna and Bueno, 2008)
External variables			Software quality
			System capability
			Software flexibility
			Social influence
		Adjustment	
		Anchor	
	Subjective Norm	Subjective Norm	
	Voluntariness	Voluntariness	
	Image	Image	
	Job Relevance	Job Relevance	
	Output Quality	Output Quality	
	Result Demonstrability	Result Demonstrability	
	Experience	Experience	
Perceived Usefulness	Perceived Usefulness	Perceived Usefulness	Perceived usefulness
Perceived ease of use	Perceived Ease of use	Perceived Ease of Use	Perceived ease of use
Attitude toward using	Attitude Toward Using		
Behavioral intention to use	Behavioral Intention to Use	Behavioral Intention	Intention to use
Actual system use	*Actual System Use*	*Use Behavior*	*Usage behavior*

Success Models				
Original IS Success Model (Delone and McLean, 1992)	**Extended IS Success Model** (Seddon, 1997)	**Updated IS Success Model** (Delone and McLean, 2003)	**OSS success model A** (Lee, Kim and Gupta, 2009)	**OSS success model B** (Midha and Palvia, 2012)
System Quality	System quality	System Quality	Software quality	Extrinsic cues
Information quality	Information quality	Information Quality		
User satisfaction	User satisfaction	User satisfaction	User satisfaction	Intrinsic cues
		Service quality	Community service quality	
	Perceived usefulness			
		Intention to use		
Use		Use	OSS Use	
Individual impact	*Individual net benefits*	*Net benefit*	*Individual net benefits*	*Market success*
Organizational impact	*Organizational net benefits*			*Technical success*
	Societal net benefits			

Table 1 - Comparison of Popular Acceptance and Success Models

(Acceptance and Success Constructs printed in Italic Font)

Drawing on TAM, Gallego, Luna and Bueno (2008) propose a model to explain the individual attitude towards OSS adoption. The authors introduced four constructs: software quality, system capability, social influence and software flexibility. Their study shows that software quality and system capability has a statistically significant impact on the perceived usefulness. In addition, they show that social influence and software flexibility have a statistically significant impact on the perceived ease of use. However, it should be noted that their additional four constructs (software quality, system capability, software flexibility and social influence) share many similarities with the IS/OSS success models we discuss in the following.

IS/OSS success stream of research Based on a comprehensive review of both conceptual and organization studies, Delone and McLean (1992) describe six major dimensions of an IS success taxonomy: "System quality, information quality, use, user satisfaction, individual impact and organizational impact" (Delone and McLean, 1992). As summarized by Tate et al. (2014), countless authors such as Seddon and Kiew (1996) empirically tested the proposed constructs and suggested modifications which Delone and McLean (2003) incorporate in their updated IS success model. This model includes an additional service quality construct and measures success in terms of the net benefit provided by the IS rather than the individual and organizational impact. Thus, they include findings of the extended IS success model proposed by Seddon (1997) that contains two additional constructs: perceived usefulness and societal net benefit. Lee, Kim and Gupta (2009) draw on findings of the updated IS success model to develop an OSS success model. They use four constructs (software quality, community service quality, OSS use and user satisfaction) to explain their OSS success construct's individual net benefits. In their model, Software quality has a statistically significant influence on OSS use and user satisfaction. Community service quality has a significant impact on user satisfaction which in turn has a significant effect on OSS use and individual net benefits. Furthermore, OSS use has a statistically significant impact on individual net benefits. Midha and Palvia (2012) propose a different OSS success model. Here, the authors differentiate OSS success by two constructs: Market success and technical success. They show that the technical success is determined by the two extrinsic cues license type and technical success as well as the two intrinsic cues complexity and modularity. The market success is determined by the extrinsic cues license type, user base and language translations.

Looking at the different constructs presented in IS acceptance and success research it becomes clear that there are huge overlaps (see for example Table 1). We argue that success models are essentially extended versions of the acceptance models presented. In addition, most of the models are only slightly modified and/or combined versions of Davis (1989) and Delone and McLean (1992). While we agree that for example the Original and Updated Delone and McLean IS Success Model triggered hundreds of subsequent works on IS Success (Tate et al., 2014), we do not believe that the models presented above are suitable to capture emergent decentralized IS phenomena. We

therefore agree with the statement of Tate et al. (2014) that while a vast amount of scholars used different meta-techniques to synthesize the many insights generated in the field of IS success, the question of "how we can effectively measure the success and impact of information systems remains a central question [in IS research]". Especially in a more and more decentralized and heavily interconnected world. In addition, Andrew Burton-Jones defines a multi-level view as a "blue ocean" in research regarding the success of IS, which we interpret as the need for a model that allows for different organizational levels (Tate et al., 2014). However, we argue that in the age of decentralized IS such as cryptocurrencies, which are a logical consequence of movements such as a shared and decentralized economy, the lines between individuals and organizations vanish.

3. CONCEPTUAL DECENTRALIZED INFORMATION SYSTEMS SUCCESS MODEL

3.1. Overview

Based on our discussion in the last sections, we argue in favor of taking a new perspective on IS success research as a result of dramatic societal and technological advances. While IS and OSS acceptance and success models such as TAM and Updated IS Success Model pushed the boundaries of our knowledge in both IS acceptance and success, they originated in a very different time. For example, social coding platforms, cryptocurrencies, the ever growing interconnectedness of individuals, etc. are all part of a much larger societal change towards a shared and decentralized economy and society that might follow fundamentally different principles we know very little about yet. The discussion of OSS points into the same direction and provides "empirical evidence and argumentation in support of the assertion that the aims, scope and scale of open cultural production are much wider than those of the open production of functional goods" (Cheliotis, 2009). Thus as discussed by Rai, Lang and Welker (2002) in a different context on e-commerce, we believe in the need for a new IS success model to capture emergent decentralized IS use cases. We therefore conceptualize the Decentralized IS Success Model. Here, we understand conceptual modeling as the "the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication" (Mylopoulos, 1992). Summing up our discussion from above, our Decentralized IS Success Model, aims to:

- Combine and preserve insights from IS acceptance and success models. We do so by including multiple known constructs and relationships and propose that the strict distinction between acceptance and success is not applicable in decentralized IS. For example, acceptance and success of a cryptocurrency are essentially the same.
- Capture both the development and usage side of decentralized IS. For example social coding and usage of a new cryptocurrency.
- Allow for both economical and intellectual motives in both the intention and the actual level of contribution to and usage of IS as these are suspected drivers of the decentralized development and usage of cryptocurrencies.
- Disentangle the economic from the intellectual success dimension but allow for interaction between them as well as feedback loops to societal norms and economic boundaries.

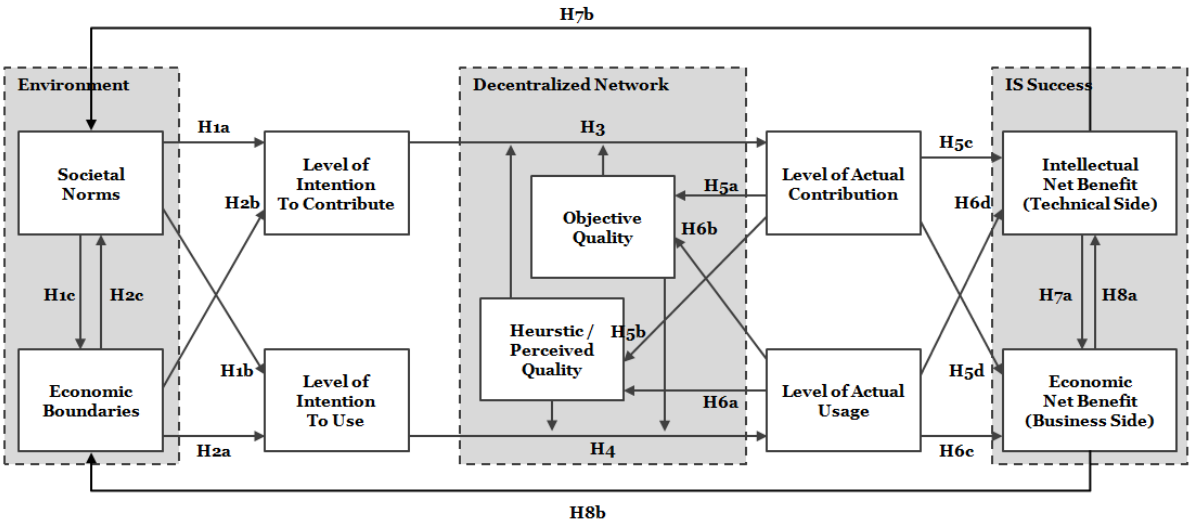

Figure 2 - Conceptual Decentralized Information Systems Success Model

In the following, we discuss the different constructs of our conceptual Decentralized IS Success Model that is presented in Figure 2 as well as their proposed relationships. To enhance the understanding, we will use the case of cryptocurrencies as an example for a decentralized IS. The rationale behind this is that both the contribution and the usage side of cryptocurrencies are highly decentralized. For example, Bitcoin itself is developed by a decentralized team of volunteers on the social coding platform GitHub. Furthermore, its usage is highly decentralized as well, in fact, the decentralized nature was the primary motivator for designing the Bitcoin protocol itself (Nakamoto, 2008). While there are a lot more stakeholders in cryptocurrencies, we primarily focus on contributors (e.g. developers contributing code and miners that contribute hardware) and users (people that use the cryptocurrency as means of payment).

The decentralized IS success model consists of ten constructs: Societal norms, economic boundaries, intention to contribute, intention to use, objective quality, heuristic/perceived quality, level of contribution, level of usage, intellectual net benefit and economic net benefit. We intentionally named some of these constructs after popular concepts in IS acceptance and success research to allow for both an easy transition and to preserve findings of the old centralized IS acceptance and success models. We grouped the two constructs societal norms and economic boundaries as the environment in which the decentralized IS emerges, exists and evolves. Furthermore, we posit that the objective quality and heuristic/perceived quality constructs define the relevant parts to understand the IS success. In addition and in congruence with our reasoning that intellectual benefits in the contribution and the usage are of rising importance to complement the traditional economic net benefit success, we define IS success by the two dimensions *intellectual net benefit* and *economic net benefit*. To account for our previously introduced requirement of a decentralized IS success model to capture both the development and the usage side of decentralized IS, we explicitly add both the intention and level of both the contribution and

usage side to the model. While the upper part of our model is primarily concerned with the contribution side, the lower part reflects usage aspects.

3.2. Societal Norms

Societal norms are intangible and not directly observable behavioral rules that directly influence the level of intention to contribute as well as the level of intention to use a decentralized IS. In addition, we propose that societal norms directly influence economic boundaries. This construct is therefore related to the social influence dimension of the OSS TAM Gallego, Luna and Bueno (2008) as well as the subjective norm of Venkatesh and Bala (2008). Societal norms vary a lot from region to region as shown by various studies based on initial findings of cultural differences among nations (Hofstede, 1983; Hofstede and Bond, 1984). This finding is also backed by results of Pereira Junior et al. (2014) regarding an examination of the attributes of the contributors of the 20 most popular projects on the social coding platform GitHub. Here, the authors show that geographical clusters exist. The authors raise the question whether such clustering "appears due to social-economic factors" or because "these social network [re] built around people from the same region" (Pereira Junior et al., 2014). Because of this reasoning, we state the following hypothesis that focuses on the contribution side of decentralized IS:

- H1a: Societal norms directly influence the level of intention to contribute to a decentralized information system

Regarding the impact of societal norms on the level of intention to use a decentralized IS, Tiwari and Pandey (2012) summarize that "various studies show that the adoption rate of open source software is very low especially in the countries like India". Combined with the reasoning of H1a, we hypothesize the following relationship between societal norms and the usage side of decentralized IS:

- H1b: Societal norms directly influence the level of intention to use a decentralized information system

We conjecture that these societal norms directly influence the economic boundaries and thus hypothesize the following relationship between societal norms and economic boundaries:

- H1C: Societal norms directly influence economic boundaries

We propose the six dimensions of the contemporary Hofstede model of cultural differences, "power distance, uncertainty avoidance, individualism/collectivism, masculinity/femininity, long/short term orientation, and indulgence/restraint" (Hofstede, 2011) as suitable dimensions for the operationalization of societal norms.

3.3. Economic Boundaries

Economic boundaries are tangible and directly observable economic facts that influence both the level of intention to contribute and the level of intention to use a decentralized IS. In addition, we propose a reciprocal relationship to the societal norms, which are also influenced by the economic boundaries. It is evident that economic boundaries are an important construct when considering the success of decentralized IS. Therefore, we hypothesize the following relationship between the economic boundaries and the level of intention to use a decentralized IS and the level of intention to contribute to a decentralized IS:

- H2a: Economic boundaries directly influence the level of intention to use a decentralized information system
- H2b: Economic boundaries directly influence the level of intention to contribute to a decentralized information system

Furthermore, we propose the following relationship between economic boundaries and societal norms:

- H2c: Economic boundaries directly influence societal norms

To operationalize the economic boundaries construct, we propose the usage of economics metrics such as Gross-Domestic-Product per Capita, Consumer Price Index (CPI), Producer Price Index (PPI), Current Unemployment Rates, Housing Stats per Capita etc. Furthermore, Maslow's hierarchy of needs theory could yield interesting insights (Maslow, 1943).

3.4. Level of Intention to Contribute

The level of intention to contribute is, similar to the intention to use construct used in models such as Delone and McLean (2003), an attitude. Thus, the level of intention to contribute precedes the level of actual contribution, which is an observable behavior. The level of intention to contribute is directly influenced by the societal norms and the economic boundaries and thus the environmental conditions. In other words, once an individual's level of intention to contribute reaches a certain threshold, we propose that its level of actual contribution is moderated by the objective and the heuristic/perceived quality of the decentralized network. For example, let's say we observe a programmer whose societal norms and economic boundaries triggered a high level of intention to contribute to the Bitcoin project on GitHub. We assume that it is likely that his actual level of contribution to the project will largely be moderated by both the objective and the heuristic quality dimensions of the decentralized development network (i.e. Bitcoin project contributors on GitHub) as well as the heuristic/perceived quality (e.g. popular press coverage of the Bitcoin project).

Subramanyam and Xia (2008) show generic motivational factors and the presence of intrinsic motives to contribute in OSS in all three regions/countries: North America, China and India. However, "North American developers exhibit stronger intrinsic motives such as sharing and learning". Furthermore, they show that Chinese developers are drawn toward projects that are

larger in scale, more modular, and universal in nature. In contrast, Indian developers with similar project preferences are mostly motivated by extrinsic motivations". Furthermore, Sowe, Stamelos and Angelis (2008) show a reciprocity between the posting and replying activities in mailing lists that are context dependent. Based on the reasoning and evidence presented above, we formulate the following research hypothesis:

- H3: An increased level of intention to contribute is associated with an increased level of actual contribution. However, it is moderated by both the objective and the heuristic/perceived quality of a decentralized network.

In the context of a cryptocurrency which is primarily developed on GitHub, one way to operationalize the level of intention to contribute are forks.

3.5. Level of Intention to Use

We define the level of intention to use in accordance with Delone and McLean (2003) as an attitude. It diverges from the level of actual usage by preceding the level of actual usage in a temporal sense. The level of intention to contribute is influenced by the societal norms and economic boundaries. This means that, if an individual reaches a certain level of intention to use a decentralized IS, we propose that its actual level of usage is moderated by the heuristic/perceived quality as well as the objective quality of the decentralized network. Sticking with our example of the cryptocurrency Bitcoin, if an individual develops an intention to use Bitcoin as a means of payment, he will likely be affected by the heuristic/perceived quality of the Bitcoin network (e.g. popular press coverage of the security of Bitcoin) as well as objective quality criteria such as the stability of the Bitcoin network itself.

Based on this reasoning and the findings presented in the section about the level of intention to contribute, we formulate the following research hypothesis:

- H4: An increased level of intention to use is associated with an increased level of actual usage. However, it is moderated by both the objective and the heuristic/perceived quality of a decentralized network.

3.6. Objective Quality

Based on the Updated D&M IS Success Model of Delone and McLean (2003), we define the dimensions of the objective quality construct as information quality, system quality and service quality. What distinguishes the objective quality construct from the heuristic/perceived quality construct is that it should only be operationalized by directly observable variables such as total commits to a cryptocurrency repository on GitHub. Based on the findings presented below, we propose that the objective quality moderates the transition from the level of intention to contribute and use to the level of actual contribution and usage:

Related literature provides some promising findings that can be used in the operationalization of the objective quality construct. For example the reliability of the code base as an objective quality dimension could be operationalized by two metrics proposed by Tiwari and Pandey (2012) : First, the number of contributors per thousand lines of code and second, the number of commits per thousand lines of code. Cosentino, Javier Luis and Jordi (2014) argue that the success of developer acquisition and retention in OSS projects depends on the openness of a project, which the authors define as the ease "for a new user to actively contribute to it". The authors identify three metrics to measure the openness of projects: "The distribution of the project community, the rate of acceptance of external contributions and third, the time it takes to become an official collaborator of the project" (Cosentino, Javier Luis and Jordi, 2014). Foucault et al.(2015), in a quantitative study, show that "the activity of external newcomers negatively impacts software quality". Another important aspect of the objective quality is the "network embeddedness", which "has strong and significant effects on both technical and commercial success, but those effects are quite complex" (Grewal, Lilien and Mallapragada, 2006).

3.7. Heuristic/Perceived Quality

The heuristic/perceived quality construct entails the same dimensions as the objective quality construct that are based on Delone and McLean (2003): Information quality, system quality and service quality. However, these dimensions should be operationalized by subjective and not directly observable things such as the image of the decentralized IS developers and/or users, social media sentiment, etc. Based on the empirical findings presented below, we propose that the heuristic/perceived quality of a decentralized network moderates the relationship between the level of intention to contribute and use and the level of actual contribution and usage:

Empirical evidence for the existence of the potentially moderating effect of heuristic/perceived quality on the level of actual contribution and usage is provided by Dabbish et al. (2012). In their study, they find that "people make a surprisingly rich set of social inferences from the networked activity information in GitHub, such as inferring someone else's technical goals and vision when they edit code, or guessing which of several similar projects has the best chance of thriving in the long term". Furthermore, the authors show that these "inferences regarding commitment, work quality, community significance and personal relevance" yield an increased collaboration in the social coding project. Subramaniam, Sen and Nelson (2009) find that restrictive OSS licenses are "negatively associated with developer interest, but are positively associated with the interest of non-developer users and project administrators".

3.8. Level of Actual Contribution

The level of actual contribution is an observable behavior. We propose that the transition from the level of intention to contribute, which we defined as an attitude, to the actual level of contribution, is moderated by the objective and the perceived quality of the decentralized network. We propose that the level of actual contribution influences both the objective and the heuristic/perceived quality of the decentralized network.

The latter proposition is based on various finding we will summarize in the following. Based on an analysis of GitHub project contribution data, (Pereira Junior et al., 2014) argue that the past contributions of a developer in a community are an important signal to other users. In addition and again based on findings based on GitHub data, Casalnuovo et al. (2015) find that the initial and the cumulative productivity of contributors are based on past and pre-existing social connections of the contributor as well as their prior experience with the programming language. Furthermore, great strength of social connectedness reduces initial productivity but increases productivity in the long run. The former is also shown by Jason T. Tsay, Laura Dabbish, James Herbsleb (2012) who indicate that "projects with highly [sic] socially connected developers are not necessarily the most active or popular projects. Further evidence of the moderating relationship of the quality of decentralized networks is provided by Sen, Singh and Borle (2012): They find that the operating system a social coding project is intended to be used on, the programming language used in the project and the license type influence the number of contributors of a project. Additional insight in the potentially moderating role of quality aspects of a decentralized network is given by Ortu et al.(2015), who demonstration the existence of communities in developer networks. In a field survey among contributors in OSS projects, Wu, Gerlach and Young (2007) show that "feelings of satisfaction and their intentions to continue with OSS development was influenced by both helping behavior and economic incentives" (Wu, Gerlach and Young, 2007). Sen, Singh and Borle (2012): find that the "number of subscribers and developers increases with the age of the OSS project" and that the "impact of developers on subscribers and subscribers on developers is positive and significant". Furthermore, they show that project characteristics such as the operating system, the programming language and the license type positively influences the number of subscribers. Based on the reasoning above, we state the following research hypotheses regarding the level of actual contribution:

- H5a: An increased level of actual contribution is associated with an increased objective quality of a decentralized network
- H5b: An increased level of actual contribution is associated with an increased heuristic/perceived quality of a decentralized network
- H5c: An increased level of actual contribution is associated with an increased intellectual net benefit
- H5d: An increased level of actual contribution is associated with an increased economic net benefit

3.9. Level of Actual Usage

The level of actual usage is the actual observable behavior of individuals, which distinguishes this construct from the level of intention to use, which is an attitude. The construct is therefore related to the actual system use and use(age) behavior constructs proposed in popular IS/OSS acceptance and success models (Davis, 1989; Venkatesh and Davis, 2000; Venkatesh and Bala, 2008; Gallego, Luna and Bueno, 2008; Delone and McLean, 1992, 2003; Allaho and Lee, 2014). For example, transactions conducted via a cryptocurrency, traded volume between fiat money and cryptocurrencies, et cetera. We propose that the level of actual usage determines both the intellectual net benefit and the economic net benefit of a decentralized IS. In addition, the level of actual usage directly influences the objective and heuristic/perceived quality of a decentralized network.

Drawing on the findings presented in the last section regarding the level of actual contribution, we propose the following relationships between the level of actual usage and other constructs of the decentralized IS success model:

- H6a: An increased level of actual usage is associated with an increased heuristic/perceived quality of a decentralized network
- H6b: An increased level of actual usage is associated with an increased objective quality of a decentralized network
- H6c: An increased level of actual usage is associated with an increased economic net benefit
- H6d: An increased level of actual usage is associated with an increased intellectual net benefit

In the context of the assessment of the success of a cryptocurrency, the transactional data stored in the publicly available blockchain might be a fruitful source to operationalize the level of actual usage of a decentralized IS.

3.10. Intellectual Net Benefit

Intellectual net benefit is the result of the actual level of contribution and the actual level of usage of decentralized networks. What distinguishes the intellectual net benefit from the economic net benefit construct is the means by which individuals are rewarded for their contribution and usage behavior. The intellectual net benefit entails mostly intangible and non-monetary incentives such as a gain in knowledge and experience and is related to the individual net benefits construct of Lee, Kim and Gupta (2009). We included this dimension primarily because OSS for example is developed by " highly qualified, young, motivated individuals, and evolves at a rapid pace" (Bitzer, Schrettl and Schröder, 2007) but is seldomly monetarily incentivized at the beginning.

Empirical evidence for the intellectual net benefit success construct is provided by various authors. For example, Bitzer, Schrettl and Schröder (2007) argue that contributors of decentralized networks have higher programming skills and users have a higher gain in using a software. In an exploratory study, Thomas and Fernández (2008) find that organizations use intellectual net

benefit metrics such as the system implementation that are not directly related to monetary rewards. Procaccino and Verner (2006) show that technical characteristics such as the meeting of "customer/user requirements and works as intended ... provides a sense of quality and personal achievement [and] are important aspects that lead to a project being considered a success." (Procaccino and Verner, 2006). Vasilescu et al. (2015) show that "both gender and tenure diversity are positive and significant predictors of productivity". Survival of one's intellectual creation could also be one aspect of the intellectual net benefit. Wang (2012) shows that survival is dependent on high-quality external networks, greater levels of user/developer participation and service quality". Furthermore, the author's show that projects targeted at technical users have a higher likelihood of surviving". Lead and core developers on GitHub "display a nuanced understanding of community participation in their assessment of success" and "they attribute increased participation on their projects to the features and usability provided by GitHub." (McDonald and Goggins, 2013). Lerner and Tirole (2001) argue that career concerns and ego gratification are both driven by the same factor, which is visible to others. Signaling theory provides an explanatory framework for the latter finding. Based on these findings we propose the following relationship between the intellectual net benefit construct and the economic net benefit as well as feedback to societal norms:

- H7a: An increased intellectual net benefit is associated with an increased economic net benefit
- H7b: An intellectual net benefit other than zero changes societal norms

3.11. Economic Net Benefit

Intellectual net benefit occurs because of the actual level of contribution and actual level of usage of the decentralized IS. It is directly influenced by the level of actual contribution and the level of actual usage. In contrast to the intellectual net benefit, the economic net benefit consists of monetary, tangible and directly observable rewards as a result of the level of actual contribution and usage of the decentralized IS. The economic net benefit construct is therefore similar to the constructs of individual organization and societal net benefit of Seddon (1997) and the net benefit construct of Delone and McLean (2003) but adopts the separation of Midha and Palvia (2012) to distinguish between the market and the technical success. Bitzer, Schrettl and Schröder (2007) show that contributors of a decentralized IS system experience lower costs of development and Stam (2009) suggest that an increased level of firm participation in OSS projects is associated with an increase level innovativeness and financial performance. We propose that the economic net benefit has both an effect on the intellectual net benefit as well as the economic boundaries that frame the decentralized IS and hypothesize that:

- H8a: Increased economic net benefit is associated with increased intellectual net benefit
- H8b: An economic net benefit other than zero changes economic boundaries

Previous studies used the number of downloads of an open source project as a proxy for its market success (see for example Grewal, Lilien and Mallapragada (2006) as well as Rai, Lang and

Welker, (2002) and Midha and Palvia (2012)). Further potential metrics for the operationalization are provided by findings of Thomas and Fernández (2008) on success metrics employed by practitioners such as business continuity, meeting of business objective, delivery of benefits, on-budget, etc. In terms of a cryptocurrency, the relative market share, maximum drawdown of the relative market share and the standard deviation of the price could be appropriate variables. The latter is backed by the fact that stability is regarded as desirable in economics (Gilles, Lazarova and Ruys, 2015).

4. DISCUSSION AND OUTLOOK

We assessed two research questions regarding the success of decentralized IS success. We find that current TAM Davis (1989) and IS Success Model of Delone and McLean (1992) based models should be combined and updated to capture the emerging decentralized nature of IS in both development and usage. Therefore, we conceptualize and propose the Decentralized IS Success Model consisting of ten constructs (societal norms, economic boundaries, intention to contribute, intention to use, objective quality, heuristic/perceived quality, level of contribution, level of usage, intellectual net benefit and economic net benefit) and their associated relationships.

The conceptualized Decentralized Information System Success Model is designed to combine and preserve insights from both existing IS acceptance and success models. Furthermore, it enables researchers to examine both the development and the usage side of decentralized IS and disentangles economic and intellectual motives in both the intention and actual level of contribution to and the usage of IS. In addition, the model includes societal and economic boundaries and feedback loops from the two success constructs intellectual net benefit and economic net benefit.

The primary limitation of the proposed Decentralized IS Success Model is that because of its conceptual nature, no empirical evidence is yet available. Nevertheless, we contribute to the IS research stream of acceptance and success by the conceptualization of a Decentralized IS Success Model that allows for the systematic assessment of differences between traditional centralized and emerging decentralized IS. Practitioners benefit from the proposed model by having a high level overview of mechanisms that yield decentralized IS success.We encourage the IS community to support us in a rigorous testing of the many propositions made as we believe that the model allows for a multitude of future research on decentralized IS. For this reason we provide various directions for the operationalization of our conceptual model.

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