The Mainstreaming of Open Source Software and its Research Impact

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KEYWORDS	ABSTRACT
Open Source Software Information Systems Research	In just over a decade, a vast range of research on open source software has been published in the field of Information Systems. By tracing the development of IS research on OSS and categorizing the different views and debates, this paper aims to uncover the rationalities underlying mainstream OSS research. It identifies two distinct academic perspectives on OSS and distinguishes between two phases of OSS debates and research within the literature. Discussing these phases and perspectives in turn, the paper calls for a more pronounced consideration of the wider implications of OSS - a third perspective which is noticeably missing from the current IS literature.

Introduction

The emergence of open source software (OSS) as a research area within Information Systems (IS) has produced a variety of debates that are as lively today as they were a decade ago. Researchers, looking to grasp the concept of open source software as a technical and organizational phenomenon, have engaged in debates using various scientific methods, frameworks and rationalities. These debates are rapidly maturing; yet, as the following pages show, IS still struggles to make sense of the wider societal and political implications of the OSS phenomenon.

This paper is divided into three main sections. The first one examines the early phase of OSS research, presenting key scholarly debates, rationalities and methods from two broad perspectives on IS: technical and organizational. This initial phase is shown to be characterized by sharp disagreements about the usefulness of OSS. Next, the paper discusses more recent OSS writings, produced against the backdrop of the increased mainstreaming of OSS. Again distinguishing between technical and organizational research perspectives, the paper demonstrates that current research displays more balanced and subtle argumentation. However, it also highlights a third and final category of broader issues that have been largely neglected in research on OSS, and calls for their inclusion into contemporary IS writing. Table 1 provides an overview of the different phases, perspectives and key research characteristics.

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Early IS Debates: Tackling the Emergence of OSS

Technical Perspective

The term OSS - denoting software that is developed collaboratively, often among widely distributed groups of volunteers, and for which the source code is freely available and modifiable - entered mainstream academic literature in the late 1990s (Fitzgerald 2005). It has been a matter of great interest to IS researchers ever since. Especially in the early years of OSS research (defined here as lasting roughly until the early/mid-2000s), scholars concerned primarily with the technical rather than organizational implications of IT found their area of enquiry dominated by a heated debate between advocates and critics of OSS (van Wendel 2005). While some scholars reacted skeptically to the idea of OSS as a software engineering revolution, its proponents hailed OSS as the "silver bullet" that could solve the decades-old "software crisis" (Brooks 1987). They emphasized the ways in which OSS represented a fundamental departure from, and challenge to, traditional methods of software development.

These discussions in IS drew on similar debates in more technical fields such as Computer Science. Thus, enthusiasts claimed that OSS enhances code security and reliability due to its peer review process, which consists of a much larger - and thus inherently more independent - pool of developers (Payne 2002). In other words, OSS would replace Brooks' Law that "adding manpower to a late software product makes it later" (Brooks 1975: 25) with what Raymond (1998) termed Linus' Law: "Given enough eyeballs, all bugs are shallow". Moreover,

many scholars maintained that, because OSS creates a dual role of user-developer while traditional software engineering separates the two, OSS developers are more loyal and thus better at coding than their proprietary counterparts (Sharma et al. 2002). OSS communities were also said to react faster to the detection of software defects because their priorities are strictly technical, while commercial software companies tend to focus on business interests (Payne 2002).

Opponents of OSS countered that OSS code is inherently less secure than that of proprietary software, as its public availability invites hackers to seek and exploit vulnerabilities (Boulanger 2005). Others, looking to the future, warned that OSS may well fall victim to its own success, as thriving projects become increasingly complex and attract new developers who lack the skills of the initial coders (Fitzgerald 2005). Finally, some researchers disputed the self-image of OSS as a fundamental IS innovation: after all, peer review, configuration management, release management, daily builds, online collaboration and other key OSS concepts are well known to traditional software developers (Fuggetta 2002; Fitzgerald 2005).

Despite their stark differences, both sides of this debate shared at least three characteristics. First, the framework underlying much of the early technical debate was an engineering rationality, concerned with the construction of technical systems and the respective merits of different IS development approaches in achieving quality, reliability and efficiency. Second, a latent technological determinism could be discerned, since for all the above writers, the construction of OSS determines its quality - which, in turn, determines its potential impact. Finally, due to the novelty of OSS research, this period did not produce large-scale empirical studies, instead relying mainly on prescriptive approaches to software development, some of which bordered on speculative and even propagandistic. As will be seen below, this dynamic has now largely changed, as the debate has matured and become more nuanced. First, however, it is necessary to review the strand of literature that focuses on the organizational implications of IS, and how the emergence of OSS was tackled here.

Organizational Perspective

In the initial phase of OSS research, scholars interested in OSS as an organizational phenomenon generally looked at two distinct issues, namely the coordination of OSS projects and the motivation of OSS developers. The latter - understanding why people engage in behavior that seemingly contradicts long-held assumptions about *homo oeconomicus* - is regarded as the most common IS research question on

OSS (Scacchi 2007). One set of explanations stressed the importance of intrinsic factors in motivating developers. These include a desire for fun, feelings of obligation to and identification with the community, and - perhaps most controversially among both OSS skeptics and supporters - altruism (Lakhani and Wolf 2003; Rossi 2004). Conversely, authors employing more traditional economic models focused on the role of extrinsic motivators such as gaining a reputation, learning and improving skills to secure advantages in the job market, and meeting personal software needs (Hars and Ou 2002; Lakhani and Wolf 2003; Lerner and Tirole 2002).

Compared to the technical debates discussed in the previous section, these viewpoints gave much more weighting to the social factors of OSS production. What is more, both sides of the debate employed empirical methods such as developer surveys to make their case, though with mixed results; Hars and Ou (2002) arguing for the dominance of extrinsic motivations, Lakhani and Wolf (2003) doing the same for intrinsic ones. However, given that such studies by definition reflect the potentially distorted view developers have of themselves, the more interesting question seems to be how intrinsic and extrinsic motivators interact, both within communities and individual developers. For example, a useful synthesis might argue that intrinsically motivated developers get OSS projects started, while extrinsically motivated ones are necessary for the developer pool to achieve critical mass (Rossi 2004).

As mentioned above, the other early research question on the organizational implications of OSS dealt with the coordination of OSS communities. Here, different underlying rationalities informed two areas of discourse. The first centered on Raymond's (1998) oft-cited claim that OSS projects resemble bazaars, with a large number of individually motivated developers working under no centralized coordination process (though perhaps under the guidance of a "benevolent dictator"). This assertion, which implies a distinct lack of norms, was dismissed as too simplistic by some. Alternative models likened OSS groups to an academic community with informal rules akin to those found in science (Bezroukov 1999). Whether bazaar or academia, the rationality behind such metaphors was administrative, as they focused primarily on the perceived organizational structure of developer communities.

Though similar, the debate around the idea of OSS communities as gift economies tackled the issue using a more explicitly economic rationality. Van Wendel (2005) explains that this model identified gifts, rather than money, as the principal currency exchanged between OSS developers, who adhere to a latent principle of reciprocity. Counterarguments

were equally founded in economic theory, arguing that while gift economies presuppose resource abundance, coding talent is in fact a scarce resource (Iannacci 2002).

Current IS Debates: Acknowledging the Mainstreaming of OSS

The arguments and debates examined above - both technical and organizational - were formulated largely as a response to the emerging nature of OSS. Recently, however, OSS has undergone a number of significant developments. It has been commercialized, is widely adopted and enjoys broad success; in short, it has now become a mainstream phenomenon. Fitzgerald (2006) goes so far as to refer to the outcome of this transformation as "OSS 2.0". Naturally, this development has also reshaped the academic debate on OSS, which has matured significantly.

With a larger pool of evidence (including comprehensive case studies) to rely on, OSS literature has become less speculative, utilizing empirical methods to draw a more balanced and nuanced picture of OSS. Moreover, as the involvement of commercial entities in OSS projects intensifies, scholars now describe OSS as a business model rather than just a technology model (Krishnamurthy 2005). Finally, there has been an increase in analytical writing linking OSS to existing IS theories and methodologies (Sahraoui et al. 2007; Scacchi 2005; Warsta and Abrahamsson 2003). The following sections examine these and other recent developments in technical and organizational OSS research.

Technical Perspective

The current debate on the merits of OSS as a development method is less heated than it was immediately after OSS emerged on the IS academic radar. Examples such as Linux, Apache and Mozilla Firefox have demonstrated that OSS can indeed produce high quality products with wide market penetration; at the same time, thousands of projects hosted on SourceForge, a web-based code repository for OSS, remain undeveloped and abandoned (Fitzgerald 2005). Thus, OSS development is now rarely described as a panacea that, by its very nature, guarantees high-quality software. Equally, however, it cannot be dismissed it as a mere fad or a poor man's version of classic software engineering, as even its most vocal critics admit (Glass 2005). A more even-handed consensus has developed, which views OSS as an "alternative community-intensive socio-technical approach to develop software systems, artifacts, and social relationships" (Scacchi 2007: 464).

Whether or not "OSS 2.0" projects produce better

software than traditional methods depends largely on the context of the project in question. In fact, according to some, the key success factor lies in an intelligent incorporation of well-established software engineering principles such as rigorous design and analysis (Fitzgerald 2006). Thus, rather than debating whether OSS is a revolution or traditional software development in disguise, a more compelling analytical question arises: what aspects of OSS can be employed to advance and expand existing IS methodologies?

Sahraoui et al. (2007), for instance, approach this issue from the perspective of agile software engineering. Using Mozilla Firefox and Apache as case studies, they discover marked similarities between the agile development process and that of OSS (although they maintain that the philosophical, motivational and economic considerations of the two methods vary considerably). By employing case studies and recasting OSS processes into existing frameworks, such analytical articles can foster the creation of new theoretical knowledge and hypotheses which can then be further tested - arguably a more useful avenue for the study of OSS as a technological phenomenon than earlier debates focusing solely on its technical merits.

Organizational Perspective

IS research on the organizational dimension of OSS has seen a similar shift in recent years. Again, one detects a growing realization that both the motivation of individual OSS developers and the coordination of their work is context-dependent. Thus, empirical research demonstrates that not all OSS developers fit the common perception of "hackers" using unstructured work methods (Weinstock and Hissam 2005), and that, at any rate, the motivational and indeed demographic homogeneity of the hacker community is greatly exaggerated (Ghosh 2005; Lin 2007). Similarly, it is now widely accepted that OSS projects exhibit a variety of social structures and avenues of communication (Crowston and Howison 2005).

Against this backdrop, interest in developer motivation has decreased somewhat, and closer attention is being paid to the commercial actors in the OSS arena and their particular interests. An increasing number of firms, from Amazon to IBM to the New York Stock Exchange, are supporting their business processes by employing OSS in some fashion (van Wendel 2005). Adding to this dynamic is the growing number of paid OSS developers. The lines are being blurred to such an extent that "Microsoft can appear to satisfy the definition of an open source company, while ... Red Hat can appear to resemble a proprietary software company" (Fitzgerald 2006). Such de-

velopments are best understood using an economic rationality, and as the following paragraphs show, this is indeed the case for recent research in this area.

Commercial motivation for OSS involvement is driven by a desire to gain strategic competitive advantage vis-à-vis other firms (Fitzgerald 2006). Companies may choose to develop and provide OSS themselves, adopt OSS products in the development of their own proprietary software, or simply use OSS development methods and practices (Ziemer et al. 2008). This variety has produced several options for commercial firms to make use of OSS, ranging from strategic partnerships in which the company provides customer support while an OSS community supplies the code (Krishnamurthy 2005) to promoting OSS adoption in order to undermine a dominant competitor (van Wendel 2005). What is becoming increasingly obvious is that earlier claims that OSS would struggle to achieve widespread market adoption - ostensibly because customers are more interested in "free beer" than "free speech" (Feller and Fitzgerald 2002) - have been refuted; most visibly by OSS products such as Mozilla Firefox, which is arguably successful not because it is free to download, but because its source code is open and allows extensive customization.

The discourse on OSS in a commercial context is still in its infancy, as researchers attempt to combine economic models and assumptions with the idiosyncrasies of OSS organizations. It is apparent, however, that the focus on straightforward explanations of individual motivation and all-encompassing metaphors and frameworks of OSS project coordination are being replaced by more subtle examinations of the organizational aspects of OSS and its growing commercialization. Yet the phenomenon of OSS has research ramifications far beyond the technical and organizational realms; it is to these issues, and the lack of IS academics examining them, that this paper now turns.

Missing IS Debates: Addressing the Wider Implications of OSS

So far, this paper has discussed IS literature that approaches OSS as a technical and an organizational area of study. It has shown that these two bodies of debate have matured since the emergence of OSS in mainstream IS academia. In addition to contemplating the benefits and drawbacks of OSS, scholars are increasingly utilizing case studies to support theoretical and analytical reviews of various OSS characteristics. This will, over time, lead to more a fundamental understanding of the various processes at work in the development and coordination of OSS.

However, despite a growing awareness of the sub-

tleties of many aspects of OSS, IS researchers generally continue to base their writings on the same underlying frameworks: an engineering rationality concerned with the construction of OSS as a technical artifact, and administrative and (increasingly) economic rationalities to understand the organizational structures of OSS actors, both commercial and non-commercial. However, the implications of OSS are wider than these research foci suggest. Perhaps because of its unexpected rate of success, OSS - and the ideas behind it - are routinely discussed in legal, socio-economic and political contexts. Yet IS scholars are largely absent from these debates.

This is not to suggest that there has been no IS contribution whatsoever in these areas of study. To give one example, some writers have closely examined the question of deploying OSS in developing countries (Camara and Fonseca 2007; Papin-Ramcharan and Soodeen 2007; van Reijswoud and Mulo 2007). However, most of these frame their arguments in technical terms, revolving around the implementation or evaluation of OSS systems in developing countries. Because of this, they fail to fundamentally depart from the engineering rationality described above. Critical IS papers on issues such as what development means, and what role OSS and information technology in general can play in this question, are not easy to find (Walsham and Sahay 2005).

Due to this gap, it appears that the discussion of the wider issues surrounding the idea of OSS - societal, legal and political - has been left to non-IS scholars (Benkler 2006; Lessig 2005; Weber 2004). Yet at the heart of this debate lies the phenomenon of OSS, and that remains inherently an IS issue. The absence of IS from the study of its wider impact is regrettable, even more so because the field would surely have much to say about the hints of technological determinism that characterize some of the legal and political appropriations of OSS research. Whether IS will take up this challenge in the future remains to be seen.

Conclusion

This paper has demonstrated how IS research on OSS has developed over the past decade. It has placed a particular emphasis on the impact of the mainstreaming of OSS on this large-scale debate and the main viewpoints, rationalities and research types employed in the literature. Two key perspectives on OSS have been presented: one the one hand, a technical framework that initially compared the respective values of OSS and proprietary software, and has since moved to a more nuanced appreciation of OSS in the context of existing IS methods; and on the other hand, an organizational understanding that focused on a discussion of motivational factors

and coordination methods before adding further considerations to its core debates, such as the commercialization of OSS and its business viability.

Needless to say, any attempt to neatly divide ongoing academic discussions into distinct phases and perspectives imposes artificial and sometimes arbitrary boundaries on distinctions that are inherently fluid and not always mutually exclusive. The scope of this paper did not allow for a thorough, methodologically rigorous review of IS literature on OSS; instead, a snapshot of relevant writing was employed to illuminate the state of affairs in a young research area. Nonetheless, the findings suggest that a more detailed study would come to the same overall conclusions. Testing this hypothesis on a larger scale might be an avenue for further research.

At any rate, the considerable amount of IS research on OSS, produced over a relatively short time span, speaks to the rigor with which the topic has been approached in IS thinking. Yet, as the final section has shown, the IS field largely omits from its discussions key considerations on the broader socio-economic and political impact of OSS. Nevertheless, the debate on OSS remains highly dynamic and timely, and a dedicated IS debate on its wide-scale implications may yet emerge.

	Early Debates (until early 2000s)	Current Debates (since early 2000s)
Technical Perspectives	• Debates regarding merits of OSS as revolutionary development method • Disagreements on OSS security, reliability, sustainability and novelty • Latent technological determinism and lack of large-scale empirical data	• More nuanced debates, balanced arguments and gradual consensus • Understanding of importance of project context • Usage of OSS concepts enhance existing IS theories and methods
Organizational Perspectives	• Discussion of intrinsic vs. extrinsic factors in OSS developer motivation • Administrative and economic metaphors of OSS coordination: bazaars, academia, gift cultures	• Increased recognition of OSS diversity; de-emphasis of "hacker" culture and individual motivators • Focus on case studies of commercial participation in OSS
Wider Perspectives	• Traditional engineering, administrative and economic rationalities fail to account for legal, societal and political impact of OSS • Such questions are covered in other fields but remain under-represented in overall IS body of work on OSS	

Table 1: Key Characteristics of OSS Research in IS grouped by Perspectives and Phases

References

Benkler, Y. (2006) *The Wealth of Networks: How Social Production Transforms Markets and Freedom*. New Haven, CT: Yale University Press.

Bezroukov, N. (1999) Open source software development as a special type of academic research: Critique of vulgar Raymondism. *First Monday*. 4(10) http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/696/606.

Boulanger, A. (2005) Open-source versus proprietary software: Is one more reliable and secure than the other? *IBM Systems Journal*. 44(2) pp.239-248.

Brooks, F.P. (1975) *The Mythical Man-Month: Essays on Software Engineering*. Reading, MA: Addison-Wesley.

Brooks, F.P. (1987) No Silver Bullet: Essence and Accidents of Software Engineering, *IEEE Computer*. 20(4) pp.10-19.

Camara, G. and Fonseca, F. (2007) Information Policies and Open Source Software in Developing Countries. *Journal of the American Society for Information Science and Technology*. 58(1) pp.121-132.

Crowston, K. and Howison, J. (2005) The social structure of free and open source software development. *First Monday*. 10(2) http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/1207/1127.

Feller, J. and Fitzgerald, B. (2002) *Understanding Open Source Software Development*. London: Addison-Wesley.

Fitzgerald, B. (2005) Has Open Source Software a Future? In Feller, J., Fitzgerald, B., Hissam, S.A. and Lakhani, K.R. (Eds.) *Perspectives on Free and Open Source Software* (pp.93-106). Cambridge, MA: MIT Press.

Fitzgerald, B. (2006) The Transformation of Open Source Software. *MIS Quarterly*. 30(3) pp.587-598.

Fuggetta, A. (2003) Open source software - an evaluation. *Journal of Systems and Software*. 66(1) pp.77–90.

Ghosh, R.A. (2005) Understanding Free Software Developers: Findings from the FLOSS Study. In Feller, J., Fitzgerald, B., Hissam, S.A. and Lakhani, K.R. (Eds.) *Perspectives on Free and Open Source Software* (pp.23-46). Cambridge, MA: MIT Press.

Glass, R. (2005) Standing in Front of the Open Source Steamroller. In Feller, J., Fitzgerald, B., Hissam, S.A. and Lakhani, K.R. (Eds.) *Perspectives on Free and Open Source Software* (pp.81-92). Cambridge, MA: MIT Press.

Hars, A. and Ou, S. (2002) Working for Free? Motivations for Participating in Open-Source Projects. *International Journal of Electronic Commerce*. 6(3) pp.25-39.

Iannacci, F. (2003) The Economics of Open-Source Networks. *Communications & Strategies*. 48(4) pp.119-138.

Krishnamurthy, S. (2005) An Analysis of Open Source Business Models. In Feller, J., Fitzgerald, B., Hissam, S.A. and Lakhani, K.R. (Eds.) *Perspectives on Free and Open Source Software* (pp.279-298). Cambridge, MA: MIT Press.

Lakhani, K. and Wolf, R. G. (2003) Why Hackers Do What They Do: Understanding Motivation Efforts in Free/Open Source Software Projects, MIT Sloan Working Paper 4425-03, MIT Sloan School of Management.

Lerner, J. and Tirole, J. (2002) Some Simple Economics of Open Source. *Journal of Industrial Economics*. 52(2) pp.197–234.

Lessig, L. (2005). Open Code and Open Societies. In Amant, K. St. and Still, B. (Eds.) *Handbook of Research on Open Source Software: Technological, Economic, and Social Perspectives* (pp.349-360). Hershey, PA: Information Science Reference.

Lin, Y. (2007) Hacker Culture and the FLOSS Innovation. In Amant, K. St. and Still, B. (Eds.) *Handbook of Research on Open Source Software: Technological, Economic, and Social Perspectives* (pp.34-46). Hershey, PA: Information Science Reference.

Papin-Ramcharan, J. and Soodeen, F. (2007) Open Source Software: A Developing Country View. In Amant, K. St. and Still, B. (Eds.) *Handbook of Research on Open Source Software: Technological, Economic, and Social Perspectives* (pp.93-101). Hershey, PA: Information Science Reference.

Payne, C. (2002) On the security of open source software. *Information Systems Journal*. 12(1) pp.61-78.

Raymond, E. (1998) The Cathedral and the Bazaar. *First Monday*. 3(3) http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/578/499.

van Reijswoud, V. and Mulo, E. (2007) Evaluating the Potential of Free and Open Source Software in the Developing World. In Amant, K. St. and Still, B. (Eds.) *Handbook of Research on Open Source Software: Technological, Economic, and Social Perspectives* (pp.79-92). Hershey, PA: Information Science Reference.

Rossi, M.A. (2004) Decoding the 'Free/Open Source (F/OSS) Software Puzzle': A Survey of Theoretical and Empirical Contributions. Department of Economics Working Paper 424, University of Siena.

Sahraoui, S., Al-Nahas, N. and Suleiman R. (2007) An Agile Perspective on Open Source Software Engineering. In Amant, K. St. and Still, B. (Eds.) *Handbook of Research on Open Source Software: Technological, Economic, and Social Perspectives* (pp.141-153). Hershey, PA: Information Science Reference.

Scacchi W. (2005) Socio-Technical Interaction Networks in Free/Open Source Software Development Processes. In Acuña, S.T. and Juristo, N. (Eds.) *Software Process Modeling* (pp.1-27). New York, NY: Springer Science+Business Media Inc.

Scacchi, W. (2007) Free/Open Source Software Development: Recent Research Results and Emerging Opportunities. In Zelkowitz, M.V. (Ed.). *Advances in Computers* (pp.243-269). Vol. 69.

Sharma, S., Sugumaran, V. and Rajagopalan, B. (2001) A frame work for creating hybrid-open source software communities. *Information Systems Journal*. 12(1) pp.7-25.

Walsham, G. and Sahay, S. (2005) Research on Information Systems in Developing Countries: Current Landscape and Future Prospects. *Information Technology for Development*. 12(1) pp.7-24.

Warsta, J. and Abrahamsson, P. (2003) Is Open Source Software Development Essentially an Agile Method? In Feller, J., Fitzgerald, B., Hissam, S.A. and Lakhani, K.R. (Eds.) *Taking Stock of the Bazaar: Proceedings of the 3rd Workshop on Open Source Software Engineering* (pp.143-147). Portland, Oregon.

Weber, S. (2004) *The Success of Open Source*. Cambridge, MA: Harvard University Press.

van Wendel de Joode, R. (2005) *Understanding Open Source Communities: An Organizational Perspective*. Enschede: Febodruk BV.

Ziemer, S., Hauge, Ø., Østerlie, T. and Lindman, J. Understanding Open Source in an Industrial Context. In SITIS 2008: Proceedings of the 4th IEEE International Conference on Signal-Image Technology & Internet-Based Systems. Bali, Indonesia. pp.539-546.