Toward an Enacted Approach to Understanding OSS Developers Motivations

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ABSTRACT

A large part of the existing literature on Open Source Software (OSS) projects identifies the motivation factors predicting the participation level of members. However, the effective satisfaction of developers toward their project still remains a managerial and theoretical challenge. So, it is also consistent to assess how the effective participation of developers in OSS projects makes sense of their own motivations. This article uses the enactivist approach and considers that motivations are not simple antecedents to actions but are shaped by actions as well. The empirical analysis delivers the results of a survey administrated to participants of business OSS projects. The results reveal reputation, reciprocity and expected professional opportunities as the most positively influenced variables. However, learning motivations and ideology toward open source beliefs and values are the lesser influenced ones. These results counterbalance prior empirical researches which have observed a strong predicting power of both variables on expected participation level of participants. This study suggests that participation seems to make sense regarding motivations for which developers have some visible indicators of their personal achievement.

Keywords: *Attitude, Developers, Enactivism, Involvement, Motivations, Open Source, Participation, Programmers, Sourceforge*

INTRODUCTION

A large part of the literature focuses on identifying extrinsic and intrinsic motivations of OSS project participants. Most cited factors are: learning and developing competences (Lakhani & Von Hippel, 2003), enhancing reputation toward peers (Lerner & Tirole, 2000; Scacchi, 2006), acquiring job opportunities (Hann et al., 2004), and contributing to open source ideology (Stewart & Gosain, 2006; Von Hippel & Von Krogh, 2003), etc. These incentives, however, do not ensure sustained participation of members along the project's life-cycles (Fang & Neufeld, 2009; Dahlander & Magnusson, 2005). As a whole, project teams

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are affected by high turnover (Von Hippel & Von Krogh, 2003) and 80% of projects turn out to be non-active projects (Hunt & Johnson, 2002). Members having no contractual obligations toward the projects remain free to leave team. Most of them stop contributing when their personal needs are satisfied (Shah, 2006), and, as a consequence, a lot of projects are aborted or abandoned before the beta version software has been distributed (Stewart & Gosain, 2006). Thus, the effective satisfaction of developers toward their project still remains a managerial and theoretical challenge. Beyond the analysis of extrinsic and intrinsic motivational factors predicting an expected active participation of project members, the question ought to be reversed: how does the effective participation of developers in OSS projects make sense of their own motivations? In other words: how their motivations are influenced by their implication level.

This article addresses this issue with the enactivist approach (Weick, 1988), considering individual motivations as not straightforward antecedents to the action but as being shaped during the action. Referring to the Theory of Planned Behaviour (Ajzen, 1991; Taylor & Todd, 1995b) and Social Cognitive Theory (Compeau & Higgins, 1995), we consider participation as distinguished from indivisible emotional and psychological antecedents (Bagozzi & Utpal, 2006; Benbya et al., 2007). The objective of the article is to assess the influence of developers' participation on their *implication*, *attitude* and *motivations*. The empirical analysis provides a survey of participants in open source business projects hosted on SourceForge. The results reveal that developers' participation level mainly positively influences their motivations in terms of *reputation*, *expected reciprocity* and *professional opportunities*. However, *motivations to learn* and to contribute to the *open source ideology* are weakly concerned. These results contradict prior empirical researches that had observed strong predicting power of both variables on expected participation levels of members. The conclusion suggests that participation seems to make sense regarding motivations for which developers have some visible indicators of their personal achievement.

LITERATURE REVIEW

Open source communities are considered as hybrid forms between private and collective models (Von Hippel & Von Krogh, 2003), putting into question traditional economic theories according to which agent behaviours and decisions are based on cost reduction and profit maximisation (Bonaccorsi & Rossi, 2003). OSS communities infuse individual and social incentives regulating participation of developers. However, the lack of consensus about factors efficiently predicting a sustained participation level motivates us to leave this kind of approach that isolates motivations from actions by which they are shaped. The literature analysis considers that intrinsic and extrinsic motivations of developers are modelled by their effective participation during the project. We postulate that actions provided by project members make sense of their own incentives. The enactivist approach allows conceiving motivations not as antecedents to participation but as dependant variables.

The Enactivist Approach of Motivation-Participation Relation

"An explorer can never know what he is exploring until it has been explored" (Bateson, 1972). By this perspective, we may consider that motivations sustaining the active behaviour of one person over time cannot be considered as isolated antecedents to his/her actions. Enactivism is often associated with *autopoïetic* theory (Maturana & Varela, 1992) which postulates that, like a biological organisms, a system continually self-produces itself in function of its on-going interactions with its environment. The term 'enactment' expresses the idea that when people act, they bring events and structures into existence (Weick, 1988). The enactment is viewed as a twofold social process by which people model material and symbolic records

of their actions (Smircich & Stubbart, 1985, p. 726). First, on the basis of preconceptions, people isolate portions of the field of experiences for closer attention. Second, they act within the context of these bracketed elements in the direction of preconceptions (Powers, 1973). Thus, action tends to confirm preconceptions.

In Management Science, the enactivism has been especially developed by Weick (1988) who suggests, "people who act in organizations often produce structures, constraints, and opportunities that were not there before they took action" (Weick, 1988, p. 306). In other words, the environment does not prescribe the way a person must behave but proscribes only some behaviours perceived to be inconsistent (Maturana, 1987). So, he/she can only be aware of the significance of his/her actions by accomplishing them. In this sense, enactivism is also related to the theory of sensemaking (Weick, 1988) which considers that, when people are implicated in a social context, they engage in forthcoming events from which they will retrospectively extract cues and make sense of their actions. Sensemaking "is a way station on the road to a consensually constructed, coordinated system of action" (Taylor & Van Every, 2000, p. 275).

According to Weick et al. (2005, p. 409), people develop explicit efforts of sensemaking when they perceive their environment as being different from the one they expected. Then, they look for reasons to pursue their actions. These reasons are pulled from frameworks such as institutional constraints, organisational perspectives, inherited traditions from predecessors, environmental obligations, etc. In other words, incentives to act in a project do not prefigure the ones that will maintain the activity. A great deal of research in open source (Gacek & Arief, 2004; Ye et al., 2004; Crowston et al., 2006) has found that during the process of software development, several changes in participation occurs as users shift, without any obvious reasons, from passive to active users and from active users to developers. Sustained participation in an open source project turns out to be a complex mechanism where motivational factors shape and are shaped by behaviour over time. This reflexivity is illustrated by the empirical research of Roberts et al. (2006) who view motivations as belonging to a pattern resembling overlapping roof tiles or scales structured by prior actions and results obtained. In the same vein, by participating, a developer can raise some unexpected motivations. McLure Wasko and Faraj (2005) show that people make their knowledge available on an open electronic network, not only because they perceive it as likely to improve their reputation (preliminary incentive), but essentially because they are implicated in the dynamic of the group (emerging incentive). The observations provided by Demazières et al. (2006) confirm this structuring effect of participation on incentive factors of open source developers. According to the authors, the classical economic approach, which postulates that individual behaviours are the results of preconceived models, does not match the reality of OSS communities. Developer engagement is gradually sustained in function of the social process developed with other participants and through experiences (pp. 8-9).

Developer Behaviour

Popular IS research studies on individual behaviour toward IT (Davis et al., 1989; Barki & Hartwick, 1994; Venkatesh et al., 2003; Wixom & Todd, 2005) conceptualized theoretical lenses with the Theory of Reasoned Action (Ajzen & Fishbein, 1980), the Theory of Planned Behavior (Ajzen, 1991; Taylor & Todd, 1995a) or the Social Cognitive Theory (Compeau & Higgins, 1999). This theoretical framework distinguishes attitude, involvement, and participation.

Attitude corresponds to positive or negative feelings to a stimulus. Ajzen and Fishbein (1980) suggest attitude as being evaluated by a bipolar affective or evaluative dimension. The scales generally used oppose items such as "good" and "bad." Attitude determines the intention of somebody to perform a task and ultimately the way he/she behaves or is expected to behave (Wixom & Todd, 2005, p. 86). In an open source project, developer *attitude* can

correspond to his/her overall feeling about the announced software to be developed (its objective, functionalities, targeted users, etc.).

Involvement is defined "as a subjective psychological state, reflecting the importance and personal relevance of an object or event" (Barki & Hartwick, 1989, p. 61). Whereas attitude is an affective or evaluative judgement of a person with regard to an object or an event (Fishbein & Ajzen, 1975; Barki & Hartwick, 1994), involvement corresponds to the importance level he/she acknowledges in acting or re-acting in an appropriate way to this stimulus. Another way to explain the concept is to consider involvement as an "entanglement" by which a person and a system are "involved" to the extent that the activities of each facilitate the attainment of the ends of the other (Alavi & Joachimathaler, 1992, p. 98). Whereas involvement had been assimilated for a long time to participation, the empirical analysis of Barki and Hartwick (1989) discloses the twofold components of this psychological state as: the importance granted by the individual to the object (generally assessed with "necessary- not necessary" type of scales) and his personal relevance (generally assessed with "concern me - not concern me" type of scales). In the case of open source, developers can feel themselves more or less involved in the project because of its scope, the competency required, their own availability, and so on. Participation corresponds to the "visible part of the iceberg" and is defined as "taking part" or "contributing" to something (Vroom & Jago, 1998). In open source software, members' participation refers to the set of activities that developers perform during successive stages of a project. These activities can be linked to specific phases of systems development such as feasibility analysis, software design, programming, testing and bug fixing, documenting, etc. OSS development is not designed in a "top-down" manner, and users may contribute to this process since the source code is open to modification, enabling them to become developers and to participate in coding and fixing bugs.

In line with the argument related to the enactivist approach, we consider *participation* as the central and structuring behavioural node of *involvement* and *motivations*. In conformity with the *Theory of Planned Behaviour,* we also consider that *attitude* must be distinguished from *participation*. Such a distinction consistent with psychology research which demonstrates that the way individuals behave does not always fit with their preconceptions (Wicker, 1969; Kraus, 1973). In Management Science, *attitude* has been viewed as an antecedent to individual participation in several domains such as e-commerce (Pavlou & Fygenson, 2006), consumption (Conner et al., 1999; Bright, 2003; Maison et al., 2004), decision processes (Katz, 1985; Koslowsky et al., 1988; Cordano & Frieze, 2000), job motivations (Tubbs & Ekeberg, 1991), or health sector (Feldman & Mayhew, 1984). Concerning existing open source literature, Bagozzi and Uptal (2006) adopt a similar reasoning in order to analyse Linux users' behaviour. Our research can be considered as an extension to open source developers. However, since behaviour is not a single reaction to an external stimulus but implies an engagement with duration, the *attitude - participation* sequentiality is questioned. In a longitudinal research, Barki and Hartwick (1994, p. 75) observe that the initial attitude and involvement levels poorly influenced participation. Actually, when persons are implicated in a design process they develop some positive or negative beliefs; consequently, *attitude* and *involvement* become more the results than the antecedents of participation. The above leads to the following hypotheses:

H1: Developer participation level positively influences his/her attitude toward the OSS project.

H2: Developer participation level positively influences his/her involvement in the OSS project.

H2.1: Developer participation level positively influences his/her importance toward the OSS project.

H2.2: Developer participation level positively influences his/her personal relevance toward the OSS project

Developer Motivational Factors

Psychology literature about individual motivations traditionally draws a distinction between *intrinsic* and *extrinsic* factors (Deci, 1971, 1975). A person is intrinsically motivated when he/she does not expect any retribution apart from the pleasure of carrying out the activity by itself (Deci, 1975, p. 105). Intrinsic motivations are often considered as primitive motives (Fischhoff, 1982) and aim to satisfy human needs in terms of autonomy and competence acquisition. At the same time, individual behaviour is also shaped by extrinsic motivations that refer to rewards and sanctions likely to be used. Financial retribution or fears of being hierarchically blamed are evident examples of extrinsic motivations.

Existing literature on open source often articulates developer motivational factors with the *intrinsic-extrinsic* dialectic. However, it should be considered more as a continuum than a dichotomy (Roberts et al., 2006, p. 987). Indeed, an extrinsic motivation can be *internalised* (Deci & Ryan, 2000) when appropriated by a person who develops his/her self-regulating system. In open source communities, the ego-enhancement quest can be cited as most illustrative examples (Rossi & Bonaccorsi, 2006). At the same time, developers' expectancy toward professional opportunities because of the competences acquired can also be seen as a sort of *externalised* intrinsic motivation. While keeping in mind this continuum notion, our article aggregates both dimensions by distinguishing, on the one hand, *learning motivation, expected reciprocity* and *ideology* (intrinsic motivations) and, on the other hand, *professional opportunities* and *reputation enhancement toward peers* (extrinsic motivations).

Individual motivations in social groups (such as open source communities) are hot research topics in psychology and education science (Diener & Dweck, 1978, 1980; Dweck & Elliott, 1983). The *Goal oriented* concept is the dominant approach in individual motivation research (Elliott & Dweck, 1988). It implies making the distinction between expected learning goals and performance objectives aimed by a person in terms of ability to achieve specific tasks. In existing literature, learning goals are among the most cited motivational factors for open source participants (Ljungberg, 2000; Kogut & Metiu, 2001; Lakhani & Von Hippel, 2003; Von Krogh, 2003; Crowston et al., 2006; Stewart & Gosain, 2006). Indeed, for a developer, an open source project can represent a suitable context to knowledge and expertise sharing, as well as to discovering technical crafts and programming practice rules (for instance: the way scripts should be structured, the naming of objects and how they are used, etc.). These knowledge acquisitions correspond to *learning by doing* in the sense of Brown and Duguid (1991) who consider learning as a process embedded in action. Lakhani et al. (2005) observe that, compared to private sector software, open source communities allow a higher feeling of creativity for participants. Existing literature illustrates this feeling with several notions such as enjoying coding, fixing bugs or technical problems (Von Hippel & Von Krogh, 2003; Roberts et al., 2006).

Empirical findings in OSS projects reveal that both knowledge transfer and knowledge creation are possible because of the re-experience enabled by displaying source code and transactive group memory (Hemetsberger & Reinhardt, 2006). The authors consider that the on-line functionalities of host Forge tend to compensate the absence of face-to-face contact. For instance, comments added in code programs and CVS systems allow developers to review the process that lies behind the code developed by others. Being able to review the whole history of code development allows developers to be engaged in reflective observation and to learn from improvements and errors previously made. Recently, the results provided by Fang and Neufeld (2009) reveal that one of the factors explaining sustained members' participation on the long term is the learning developed through

interactions with other members (*situated learning*). We thus hypothesize that:

H3: Developer participation level positively influences his/her learning motivations.

Another developer intrinsic motivation is related to the identity conveyed by the open source community itself (Rossi & Bonaccorsi, 2006). This feeling of social identity corresponds to a person's affiliation to a social group: *"Social identity is the individual's knowledge that he belongs to a certain social group together with some emotional or value significance to him of this group membership"* (Tajfel, 1972). From this definition two elements can be highlighted: (1) the extent to which a person considers him/herself as belonging to a group, and (2) the feeling of pride in belonging to this group. The latter is related to a self-enhancement motive and both should be considered more as interrelated parts of a virtuous circle than straightforward antecedents of identity feelings. In a community, the social identity of participants tends to promote cooperation, and, in turn, cooperation tends to reinforce social identity (Soenen, 2006).

Formerly, open source phenomena raised with the objective of emancipating software development from the "commercial dictates" of private editors rarely allow users to check how applications have been coded. The open source community conveys rich ideological considerations (Elliott & Scacchi, 2004), and related identity feeling constitutes a regulating vector of developer participation - and management (Dahlander & Magnusson, 2005, p. 489) - in spite of classical hierarchical central authority and commercial challenges (Scacchi, 2006). Ideology is considered as the cultural environment forming individual attitudes (Scarbrough, 1990). The adherence to and the sharing of some norms, values and beliefs about open source (Stewart & Gosain, 2006) shape developers' participation. *Norms* refer to behavioural expectations (norm as opposed to removing someone's name from a project without his agreement, against splitting a project into numerous others, against using an inappropriate channel to distribute code and so on). *Values* refer to preferences for some behaviours or outcomes over others (the duty of developers to share information and help others, improving capabilities by exploring code in detail instead of settling for learning the minimum necessary). *Beliefs* are the basic assumptions referring to the underlying philosophy of the community (for instance the quality of the code produced is higher when the code is open and freely available than when it is privately developed for commercial purposes; bugs are more rapidly fixed when other people can intervene than when they are performed by fixed teams). Then effective contribution of OSS developers is likely to make sense of these ideological considerations. Thus:

H4: Developer participation level positively influences his/her open source ideological motivations.

Literature about self-determined motivations considers OSS developer behaviour as being shaped by another social incentive: the expectancy of reciprocity. Reciprocation is defined as an individual contribution to a community with the expectancy that other participants will respond similarly (Shumaker & Brownell, 1984). The Game Theory shows that whenever the pay-off of a player is questioned by a rival's choice, the cooperation durability is jeopardized (Axelrod, 1997). Reciprocation appears as a necessary condition to maintaining cooperation stability and trust over time in organizations (Arrow, 1974). Contrary to the game theory meaning, reciprocity in the OS community differs from a win-win deal into one-to-one relationships. The concept is related to a more collective dimension that could be summarized as follows: "Behave with the community members as I did with you." In this sense, reciprocity can be assimilated to altruism which acts with no counterpart expectancy except the desire to maintain some social links (Monroe, 1996).

However, electronic network-based communities sharply contrast with traditional ones

where day-to-day social life is characterized by face-to-face exchanges enforcing expectation of reciprocity through social sanctions (McLure Wasko & Faraj, 2005, p. 37). The social capital of a community is not likely to be fully recovered when transferred to an *electronic practice network* (Nahapiet & Ghoshal, 1998). For instance, in electronic networks, participants have no control over other participants' responses on the forum and no assurance that the persons they are helping will not act like "free-riders." Moreover, electronic practice networks, such as open source communities, can simply disappear if too much free-rider behaviours occur (McLure Wasko & Faraj, 2005). This reinforces the relevance of a satisfactory reciprocity shaping developer behaviour in OSS projects. Accordingly, we hypothesize:

H5: Developer participation level positively influences his reciprocity motivations.

Beyond intrinsic motivation, the *social exchange theory* (Blau, 1964) suggests that actors engaged in social relations also hope for other retributions, such as recognition by peers. Recognition builds up a person's reputation which is defined as the esteem, largely shared in the group he/she belongs to, of his/her nature and values (Bromley, 1993). Reputation supports the emergence of trust and represents the dissuasion power of people associated to their relations (Shapiro et al., 1992). Building his/her reputation means gaining respect from other open source community members (Raymond, 1999; Lerner & Tirole, 2002) which implies being able to fix bugs, to be creative in coding and to share knowledge and competency. Respect toward peers is seen as one of the reasons of the members' engagement (Fang & Neufeld, 2009). At the same time, developer reputation building is also another way to capture the attention of the environment and eventually to seek professional opportunities (Ljungberg, 2000). Contrary to commercial software market, providing the source code they develop for free is an appropriate way for developers to render their work totally visible to the community and the public (Rossi & Bonaccorsi, 2006). Thus:

H6: Developer participation level positively influences his/her reputation motivations.

Apart from the learning orientation, developer behaviour is also shaped by performance expectancy. Indeed, Dweck (1990) notes that a person may operate in both systems of learning and performance goals. In the context of OSS development, participants may expect several outcomes from their contributions. For instance, Hann et al. (2004) observed in their study that for 122 Apache project developers, potential career impacts from participation appeared as a strong motivational factor in OSS development. Other expectations put forward by preliminary research include enhancing the effectiveness of developers in their specific jobs. In this way, just like "freelance" developers, developers of OSS projects are likely to look for some professional experiences allowing them to improve their job effectiveness and to get career opportunities. At the same time, we must remain sceptical about excessive expectations. While experience and reputation gains can involve some valuable job offers, this type of side effects is very scarce (Raymond, 2000). Indeed, developers' commitments to free software are observed as having neutral, even negative consequences, from a material point of view (Demazière et al., 2006, p. 8). However, the objective of this article is not to assess how a developer can effectively reach professional opportunities, but simply how he/she can be motivated because of his/her participation in the project. Thus:

H7: Developer participation level positively influences his/her professional opportunity motivations.

RESEARCH DESIGN

Data was collected from the SourceForge website. We chose SourceForge primarily because it is the world's largest Open Source software

development website. Since February 2009, SourceForge hosted more than 230,000 projects and had more than 2 million registered users. The mission of SourceForge is to enrich the open source community by providing a centralized infrastructure for developers to control and manage OSS development (managing projects, issues, communications, and code). Thus, SourceForge provides these projects with a standard technology toolset, reducing variance in developer behaviour that could be due to differences in technology used to support workflow, code distribution, and versioning.

An early survey included open-ended questions asking project administrators about code development. Administrators of the 100 most downloaded SourceForge projects were contacted by e-mail. 34 filled the questionnaire. Qualitative data collected was used to develop the wording of social and individual incentives, developer behaviours items to be included in a second survey and performance satisfaction outcomes for hypothesis testing. A different set of projects was targeted for the second survey. We selected projects from one category on SourceForge: Software development (code generator, design, and framework). We limited the sample to one similar domain - enterprise application development - to eliminate potential variance biases across projects because of different product categories. So we excluded all projects of other categories.

Then we ensured that projects had some activity in the previous weeks in terms of contribution to the code repository, requests for bug-fixes, support, patches or features, or in terms of page views. In total, 50 projects met all criteria. A subset of these projects was randomly selected to pilot test the survey. In each project we selected the project member whose role/ position was stated as being the developer. For the pilot test, we targeted developers who were asked to complete all scale items and to answer open-ended questions, asking if any of the items were unclear, if they had problems understanding or answering any questions, or if the survey itself could have been improved. Twelve developers responded, and none of them indicated any problems regarding the survey. Personalized invitations were sent to the remaining developers of the sample. We asked participants to help us to understand which elements influenced the developer's performance, and offered to communicate the results of our study. In total, 101 developers responded to our survey from a sample size of 310 (an overall response rate of 29.7%). We eliminated 8 responses because these respondents declared receiving financial retribution for participating in the OSS project.

Most of our measurement instruments used existing validated scales from prior academic research (Barki & Hartwick, 1994; Gray & Meister, 2004; Zhao & Deek, 2004). A literature review was conducted to locate past operational measures of the constructs under investigation, and groups of questions were compiled from validated instruments to represent each construct. The wording of the identified measures was modified to fit the OSS context to be studied. All items were assessed with 5 point Likert and Osgood scales.

RESULTS

Despite the small size of our sample, we chose to conduct Structural Equation Model in order to take advantage of the richness provided compared to classical multivariate analysis methods. Moreover, because of the high number of dependant variables (8), we preferred using this technique that tests the research model as a whole instead of calculating one-to-one linear relations. Next, we proceeded to a bootstrap (Efron & Tibshirani, 1993) in order to improve the properties and the robustness of statistical estimators related to small sized samples (Godfrey, 1998, p. 60, p. 69; Chin et al., 1999).

Classically, one distinguishes three indicator categories: the absolute, the incremental and the parsimony indicators. The absolute indicators allow evaluating how the theoretical model fit the data collected. We used the Chi^2 test, but because of its sensibility to the sample size (and also to the number of parameters to be

estimated), we also applied the RMSEA. The incremental indicators assess the adjustment improvement by comparing the tested model to a more restrictive one called the "base model." We used TLI, IFI and CFI indicators (Roussel & Wacheux, 2005). The parsimony indicators are absolute or incremental adjustment measures that have been modified to give information about the parsimony of the model. The correction operated is to include the degree of freedom of the tested model and eventually of the null model. We chose the PRATIO indicator to compare the alternative model. All the treatments were done with AMOS software. To summarize, we used the TLI (Tucker & Lewis, 1973), the PRATIO, the IFI, the CFI (Bentler, 1990) and the RMSEA (Steiger & Lind, 1980) to test the fitness of data collected to the theoretical model. The first four indicators indicate a good adjustment with a value near to 1 while, a satisfactory threshold for the RMSEA is generally 0.5.

We present the results of postulated hypotheses in the research model (Figure 1). This model aims to identify how effective developers' participation influences their own motivations. More precisely, we examine the adjustment indicators of the proposed model to the theoretical model, and the square of correlation coefficients to confirm the relevance of selected variables. The tested model presents satisfactory adjustment quality levels (CFI=0.90; TLI=0.89; IFI=0.90; RMSEA=0.07, PRATIO=0.90). All are in acceptable significance thresholds (Hair et al., 1998). The Chi² by degree of freedom is equal to 1.45.

A first result confirms the linkage between *participation* (PART) and *attitude* (ATT; r=0.64). A second result reveals a same positive relation of *participation* on both *involvement* variables: *importance* (IMP; r=0.53) and *personal relevance* (PR; r=0.71). These results corroborate the results of Barki and Hartwick (1989) who observed effective participation of project team members as having a decisive influence on these psychological and emotional variables. In this sense, they did not represent straightforward behavioural antecedents.

When we examine relationships with intrinsic incentive variables, we note that the more important the participation level is, the more influenced are the variables in terms of *learning* (LEARN; r=0.64), *reciprocity* (RECI; r=0.78) and *ideology* about open source (IDEO, r=0.57). We also observe participation as positively influencing extrinsic motivations: *professional opportunities* (PROF; r=0.73) and expected *reputation* toward peers (REPU; r=0.78).

All the hypotheses are thus confirmed at a significance level of 5%. This confirms the structuring effect of developers' participation on their own motivations. However, several weight differences on each variable need to be commented upon and compared to prior empirical research.

DISCUSSION

Our research presents classical limits inherent in both the analytical methodology used and the hypothetical deductive approach. Noteworthy, this constitutes potential challenges for future investigations to use other data collection methods in order to better apprehend the open source phenomenon complexity. Our sample focused on SourceForge "enterprise application development" projects to reduce the spectrum of potential behavioural types in the open source community as a whole. Another limit is the transversal approach not taking into account the different possible cooperation and coordination forms which can emerge in a project team (Demazière et al., 2006). Moreover, the analysis delivered a "one shot result" at a specific time and did not allow a longitudinal analysis of the way research objects evolved over time.

Nevertheless, our results offer an original perspective for studying the *motivation-participation* relations in OSS projects. Indeed, this research departs traditional approaches which identify incentive factors that predict developers' participation levels in OSS projects. Thus, their engagement is postulated as a consequence

Figure 1. Research model

of prior motivational antecedents without considering the structuring effect participation may exert in return. Based on the enactivist theory, this study puts into question such sequentiality, and reversely considers that participation influences the way people are able to perceive and make sense of motivations sustaining their engagement. This approach is pragmatic in the sense that motivations are considered as being dependant on actions developers are able to carry out in the context allowed by the OSS project they are members of. Moreover, the research model does not reduce developer behaviour to straightforward effective participation levels, and includes affective and psychological components.

The results deliver also singular insights about the way participation level positively influences developers' motivations. First, developer adherence to open source beliefs appears as the lowest explained factor (r=0.57). The fact that ideological principles can remain introverted or unexpressed for individuals (van Dijk, 1995) can be a way to interpret this weak score. In any case, it counterbalances the findings of Stewart and Gosain (2006), who observed open source ideology components as a determinant of team behaviour and effectiveness (p. 13). Such a paradox is all the more significant since we used exactly the same questions and measurements of the authors (see the Appendix and p. 23 of their article). Our observations lead us to consider that, while ideological beliefs toward open source software values can represent an incentive to contribute to OSS projects, the reverse effect is less significant. This can be interpreted by assuming such activities like programming, source code submitting, interactions with other project members, as reinforcing essentially motivational factors for which the achievement is at short or mid-term.

Reciprocity appears as the most explained intrinsic motivation (r=0.78). This result differs from the empirical research of McLure Wasko and Faraj (2005) who did not identify any influence of reciprocity motivation on participant contribution. Our observations reveal a significant reverse relation and highlights the way developers stimulate expected behaviour of other participants: contributing to the project in order to incite other developers to do the same who, doing so, legitimate this incentive. *Reciprocity* does not sound like a one-to-one exchange but rather like a collective form of cooperation between people sharing the same focal points.

Regarding extrinsic motivations, expected *professional opportunities* are largely influenced by the developer participation level. While developers' engagements often have a neutral effect on career advantages (Raymond, 2000; Demazière et al., 2006), our results expand to business OSS projects - the observations previously made on popular OSS development (Von Hippel & Von Krogh, 2003; Lakhani & Von Hippel, 2003; Raymond, 1999). *Reputation* toward peers turns out to be the most influenced variable (r=0.78) and aligns with Fang & Neufeld's (2009) who observed the social identity of the developer as being one of the two factors sustaining participation in the project.

However, a more nuanced report must be carried out regarding the less significant influence of participation on learning motivations (r=0.64). Because of the literature emphasis on cognitive capabilities stimulated by open communities, we expected a stronger relation. A first possible explanation can be related to Hemetsberger and Reinhart's (2006) research which highlights the knowledge construction process on innovative open-source platforms. According to the authors, knowledge creation must be distinguished from *learning facts*. They show how platform participants (especially new entrants) might develop competence through *transactive group memory* (p. 208) which refers to project knowledge archives (codes, CVS, stored communications, etc.) where hypertext articulation allows users' contextual and intuitive explorations. In other words, knowledge and competence creation in the open source community would be possible through observational behaviour without active participation being necessary. This reminds us of how the learning process covers an abstract dimension on which individuals construct their logical mental model through reassembling information from their own experience and observations (Kolb, 1984).

A second possible explanation is in line with Roberts et al. (2006, p. 996) who observed a similar result with regard to intrinsic motivation of Apache project contributors. We keep in mind that contributors being self-determined, their intrinsic motivations may frequently not be totally in phase with the accurate objectives of the OSS project. For example, a participant could be intrinsically motivated to develop a precise functionality while spending a huge time delivering source code considered to be "pure and perfect" (the well known "scratching an itch" syndrome, as named by Roberts). All this time and energy spent can limit other participating actions more likely to sustain new learning.

A third possible explanation lies in our sample. Having limited open source projects to those reserved for corporations could imply that surveyed participants have a profile of experienced developers who have gone beyond the state of novice programmers' eager of learning and experiences in terms of programming and bug fixing. As Zimmerman et al. (2007) observe, learning is an important motivational factor for beginner developers, and we consider surveyed participants as no longer being in the same personal development mental model. For our sample, developers' motivations are more focused on other dimensions: stimulating sustained participation of other project members (*reciprocity* variable), their recognition by peers (*reputation* variable), and by firms (*professional opportunities* variable).

CONCLUSION

Thus far, the open source literature allowed us to identify, among possible intrinsic and extrinsic motivations, the ones that need to be stimulated in order to capture developers. However, as stated in the first part of the article, the highest challenge for an OSS project administrator is less to make a project attractive for developers than it is to keep a sustained active participation during the project (Fang & Neufeld, 2009). In this sense, it was consistent to move beyond the approach by which motivation factors are isolated from the actions by which they make sense. In particular, we observe perceived professional opportunities as dominating learning motivations. Reputation and reciprocity toward peers appear as strongly influenced variables, whereas ideological beliefs about open source values remain in the background. In other words, the participation seems to make sense regarding motivations if developers have some visible indicators of their achievements. For example, a developer may self-estimate his/her reputation through his/her own visibility in the project (the number of reused code pages if he is the author, his status, etc.). He/she may also perceive the reciprocity by the reactivity level of other project members (by the time delay to reply to posted messages on the forum, to fix signified bugs, etc.). In the same vein, he/she can make sense of potential professional career opportunities in function of his/her interactions

with users. However, his/her marginal learning got from a project and his/her marginal ideological contribution to the open source software values correspond to more ambiguous dimensions less easy to self-evaluate. As a consequence, if acting allows participants to make sense of their own determinations, some research issues worthy of exploration should deal with how they use their professional environment in this sense.

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