

A Comprehensive Theoretical Framework for a Better Understanding of Motivations of Participants in OSS Development Projects: A Meta-Research Approach

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ABSTRACT

Participants in Open Source Software (OSS) development projects usually contribute voluntarily without expecting direct compensation for their work. One of the central puzzles raised by the success of OSS is the motivation of the participants; why top-notch programmers choose to write software that is released for no fee. In order to respond to this peculiarity employing a meta-research method, we first identify and review theoretical perspectives from diverse disciplines including economics, sociology, political science, anthropology, psychology, and management. Then, we suggest a comprehensive framework that provides a holistic understanding of the puzzle in question. Reviewing key empirical studies based on the suggested framework, we also suggest a future research agenda.

Key words: *Open Source Software, Motivation of Programmers, Self-Interested Motivation, Altruistic Motivation, Meta-Research.*

1. INTRODUCTION

The Open Source Software (OSS) has gained much attention in recent years. This substantial attention seems to be derived not only from the fact that some OSS has developed successfully enough to compete against proprietary software rivals but also from the fact that OSS challenges the traditional economics paradigm in several respects. The challenges might come from its unique way of development as an alternative way to produce things or solve problems. Typically, OSS is developed by the Internet-based communities of programmers. Contributors usually participate voluntarily without expecting direct compensation for their works. Also, they agree to distribute their works for free, usually under a liberal license agreement which make it possible to legally adopt and improve the software developed by others. Thus the fruit of their works, i.e., the software and its full source codes, is made available to the public for free.

One of the central puzzles raised by the success of OSS is the motivation of participants. Individual motives of programmers, who spend considerable time and efforts in the

project without direct compensations, are interesting enough to explore. Thus, “why top-notch programmers choose to write code that is released for free?” has been identified as an important question to be answered [1] - [3]. Attempts to answer this question have been tried from varied theoretical perspectives. Although some studies have shown meaningful efforts to combine multiple perspectives, an inter-disciplinary, integrative, comprehensive, or holistic framework seems to be still necessary to better understand various aspects of incentives behind this complex phenomenon. The goal of this paper is to provide a comprehensive framework to better understand the motivations of participants in OSS development projects.

We first identify and review varied perspectives that are concerned with incentives, motives, or motivations of OSS project participants¹. The perspectives include theories from economics, sociology, political science, anthropology,

¹ In economics, an *incentive* provides a motive for a particular course of action that counts as a reason for preferring one choice to the alternatives. The study of economics is mostly concerned with *financial* (or *remunerative*) incentives, whereas *moral* and *coercive* incentives are more characteristic of decision studies in political science and sociology. In psychology, however, *motivation* is the driving force behind all human behaviors. For the same meaning, *motive* has been more often than not used in psychology literature. Upon the purpose of the study, there would not be a significant reason to distinguish *incentive*, *motivation* and *motive*, hence we use all the terms interchangeably in the paper.

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Manuscript receive Jul. 10, 2014; revised Aug. 11, 2014;
accepted Aug. 18, 2014

psychology, and management. Then we suggest a comprehensive framework that helps provide a holistic understanding of the puzzle in question. Finally, we provide a review of extant empirical studies, followed by discussion and conclusion along with future research agenda.

2. THEORETICAL PERSPECTIVES

In order to answer why programmers participate in developing OSS voluntarily, we take a meta-research approach by firstly identifying and reviewing varied theoretical perspectives from diverse disciplines such as economics, sociology, political science, anthropology, psychology, and management.

2.1 Self-Interested Motivation: Expectations of Direct Financial Returns

Varied perspectives rooted in humanities and social sciences have been introduced to explain various human behaviors. At the heart of economic theories is an abstract model of rational behavior of economic man who is motivated by his self-interest. Since Adam Smith published his influential book *The Wealth of Nations* in 1776, this model has provided a basis for further theoretical developments [4]. Although it may not be exactly true that all human behaviors can be explained by this economics framework, this explanation may be a good enough starting point on which to found the analysis of possible further explanations.

2.1.1 Private Investment Theory: Innovation has been quite a research topic in economics due to its dynamic economic impacts on the actors². The use of a rational economic man as a model of motivation for innovation, however, requires attention to private property rights. In innovation theories, private property rights, such as patent and copyright, have long been considered as facilitating agents for individuals and economic institutions to invent or innovate. Stressing the role of entrepreneur in the innovation process, Schumpeter [5] points out that those who succeed an innovation are rewarded by having temporary monopoly control over what they have created. This control allows innovators to gain an enhanced position in the market and related temporary profits from their innovations. “Thus it is true that there is or may be an element of genuine monopoly gain in those entrepreneurial profits which are the prizes offered by capitalist society to the successful innovator[5].”

In other words, the *private investment theory* assumes that innovation will be supported by private investment and that private returns can be appropriated from such investments [6]. Results of private investment usually result in assets and/or returns which are protected by proprietary property rights [6] - [8]. Therefore, a rational and self-interested man would invest

his private resources into research and development expecting maximization of his private returns. In turn, this theory assumes that freely revealing proprietary innovations developed with private funds will represent a loss of private profit for the innovators and so they will not be engaged in voluntary participation. The private investment theory explains well what motivates people to produce or innovate private goods.

OSS is usually distributed under the GPL, or its derivatives such as LGPL, MPL, QPL and IBMPL³, which make it legally possible for the software to be modified and distributed freely. The GPL was initially written by Richard Stallman in 1989 for the purpose of distributing programs released as part of the GNU project, an earlier OSS project for development of Unix-like operating software. As opposed to proprietary licenses, the GPL is a license to give the public more freedom instead of less. By its idea against proprietary *copyright*, it is often referred to as *copyleft* and challenges the social institution of copyright. The GPL is the first copyleft license, under which volunteering programmers decide to reveal and share their innovations and give up their possible profits from it in spite of investment of their private resources.

Along with copyleft, OSS has typical attributes of a public good. A public good is defined by two characteristics: *nonexcludability* and *nonrivalry* [10]. A public good is nonrival in a sense that one person’s consumption of the good does not reduce the amount available to anyone else. And it is nonexcludable in that the exclusion of individuals from benefiting from the good is impossible. OSS is quite a good exemplar of a public good, as being “the impossible public good[11].” Anyone can download a copy of OSS for free along with its source codes, which means it is truly nonexcludable. And because it is a digital product, it can be replicated infinitely at no cost, which means it is truly nonrival. Thus, nobody may be available to get direct profits or economic returns via copyright from provisioning OSS. Hence, it can be properly induced that the incentive to create OSS as a public good leads to go beyond the maximization of private benefits or self-interest.

2.2 Altruistic Motivation

Since the economic explanation for self-interested behaviors does not provide a suitable incentive for the provision of OSS, some may turn to the altruistic view that asserts voluntary contributions are driven by a pure generosity rather than by an expectation of rewards or returns on the contributions. On one hand, if altruism is defined narrowly as a personal disposition doing something for another at some cost to oneself, contribution to OSS projects is quite an altruistic behavior. “Open source programmers provide something for others (writing programs that have open source code) at their own cost (time, energy, opportunity costs), and therefore belong to this [altruist] category[12].”

² In much of the innovation literature, innovation is defined as something that has economic impacts. With respect to the economic impact on innovators, whether OSS is an innovation might be disputable. In conclusion, however, obviously OSS is a product of new technology and has some economic impacts on innovators, thus we view OSS as a good example of innovation.

³ They stand for General Public License, Lesser (or Library) General Public License, Mozilla Public License, Qt Public License, and IBM Public License, respectively. All these licenses share the common purpose of “freedom,” with slight technical differences. See [9] or <http://www.gnu.org/philosophy/philosophy.html#LicensingFreeSoftware> for details.

2.2.1 Kin Selection Altruism: Altruism has been widely regarded as being associated with community-interest, including sense of moral obligation to or caring for communities [13] - [15]. For example, members of a community may treat other members of the community as their kin and thus be willing to do something beneficial to others but not to themselves; this type of altruistic behavior has been termed as *kin selection altruism* [12]. For example, empirical evidence from surveys in Usenet newsgroups, though none was an OSS development community⁴, supports the proposition that people participate primarily out of community interest, i.e., *generalized reciprocity* and *pro-social behavior*, rather than self-interest [13] - [15]. It is quite true that, in fact, people do not act only out of self-interest but also forego the tendency to free-ride out of a sense of fairness, public duty, and concern for their community [15], [16].

2.2.2 Communities of Practice Theory: Viewing through the lens of the theory of *communities of practice*, Wasko and Faraj [13] take notice of the nature of knowledge being a public good. A typical OSS development project grants not only its developers but also all of its users, who may also be potential developers, the right to access, read, and modify its source code. Developers, bug reporters, bug fixers, and users, who “have different interests, make diverse contributions to activity, and hold varied viewpoints,” form a community of practice [17].

The concept of a community of practice was first introduced as “... a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice[17].” Thus, a community of practice is a group of people who are informally bounded by their common interest and practice in a specific domain. Community members regularly interact with each other for knowledge sharing and collaboration in pursuit of solutions to a common class of problems. Therefore, knowledge is situated in social contexts, and learning takes place when members of a community of practice interact with each other in their daily practice. That is, members experience learning not as a result of being taught but through engagement in the social, cultural, and technical practice of the community. Therefore, if knowledge is considered to be embedded in community rather than in individuals, it is collectively owned and maintained by the community as a public good [13].

According to this perspective, members of the community collectively contribute to its provision, and all members may access the knowledge provided. Thus, it can be argued that the motivation for knowledge exchange is not the narrow self-interest but *the care for the community* [15], and that people are

motivated to share knowledge with others due to a sense of *moral obligation* rather than an expectation of return [13].

2.3 Self-Interested Motivation: Expectations of Indirect and Non-Financial Rewards

Even though we accept that altruism exists and may explain the incentive of contribution, there still remain unanswered questions such as “relying purely on altruism makes OSS unsustainable[18],” and “altruism might at most explain the behavior of people writing software in their spare time but not the behavior of those who have devoted considerable resources of time and intellect[3].” Furthermore, the altruistic view fails to explain why programmers do not focus their generosity on more needy beings and why free-riding would be less pervasive in software industry than in other industries [2]. Also, if altruism were the primary driving force behind OSS, no one would care very much about who was credited for particular contributions, and there would be little disagreement in the process and little need for conflict resolution among developers [19]. Actually, an empirical study shows that altruism explains little of the motivation of OSS participants [12].

All these counter-altruistic arguments lead us to return back to the conventional economics theory which presumes that a person’s action is driven by his self-interest. However, we need to review other explanations that deny (or play down) altruistic drive and support self-interest drive but do not wholly rely on the expectations of direct financial returns.

2.3.1 Labor Economics, Signaling Theory, and Human Capital Theory:

From the perspective of labor economics, Lerner and Tirole [2] suggest three incentives to contribute to OSS projects: *low cost of contribution*, *career concerns*, and *ego gratification*. First, the cost of contribution is not that high for contributors, because contributors are already trained programmer and sophisticated users of the software. Second, frequent OSS contributors have had ready access to venture capital; for example, former OSS programmers started Sun and Netscape. Lastly, like anybody else, programmers value high being esteemed for their contribution by their peers. Lerner and Tirole [2] thus argue that these incentives altogether motivate programmers to contribute to the projects.

The authors’ arguments have been elaborated in their article published in the following year. They portray an individual programmer engaged in traditional cost-benefit analysis, and explicitly state that incentives of participants in OSS projects are just same as those of programmers working in commercial software company [20]. That is to say, “a programmer participates in a project, whether commercial or open source, only if she drives a net benefit (broadly defined) from engaging in the activity[20].” Therefore, programmers would participate in OSS projects and in commercial projects as well, only when they derive benefits greater than costs.

The authors define the *net benefit* as equal to the *immediate payoff* plus the *delayed payoff*, and cost as opportunity cost of time [20]. In the case of participating in OSS projects in particular, the immediate payoff or relatively short-term rewards consist of two benefits: (1) improvement of his performance by customizing the software, and (2) fun and

⁴ Newsgroups are self-organizing electronic forums where issues associated with the topic of the newsgroup are discussed. They are similar to bulletin boards where people post and respond to messages in an asynchronous messaging system. Participation in the community is voluntary and occurs when a message is posted. Little information about participants is available except for an e-mail address and what the poster voluntarily chooses to disclose [13, p.162]. Reference [14] implies that the motivation to provide ‘necessary but mundane’ tasks such as providing free help to others who pose questions on OSS help lines may somewhat differ from the motivation to provide creative tasks such as writing or debugging software.

satisfaction from more enjoyable mission than from a routine task. The delayed rewards or long-term benefits cover two distinct incentives; (1) the career concern incentives and (2) ego gratification incentives. The former refers to future job offers, shares in commercial open source-based companies, or future access to the venture capital market. The latter stems from a desire for peer recognition. From the economics perspective, since these incentives are similar in most respects, the authors group them under a single heading: the *signaling incentive* [20].

The signaling incentive seems to be an extension of *signaling theory* of labor markets, though the authors do not make this explicit. The signaling theory argues that people signal their productivity to the prospective employer by the extent of their schooling and on-the-job-training [21]. As Weiss [21] posits, the signaling theory is a direct extension of the *human capital theory*. However, the theory of human capital claims that people are rewarded with good jobs to the degree that they possess human capital, i.e., knowledge and skill achieved through training [22]. Therefore, both theories explain why more educated or trained people tend to have higher wages.

Also borrowing further from the labor economics, Hann and his colleagues [23] explain incentives of OSS participants using the concept of economic returns. They propose that OSS participation is an investment in training, that it serves as a signal of individual productive capacities to current and future employers, thus that it will lead to higher earnings in the future [23]. Preliminary results of their empirical investigation in three Apache projects are interesting; contributions per se do not lead to wage increase; however, a higher status within the project does lead to significantly higher wages [23]. In an earlier article on OSS, we can find a similar suggestion. Raymond [24] suggests that reputation among peers is virtually the only available measurement of an individual's success and status in the gift cultures like the communities of OSS. He adds some reasons why peer repute is worth playing for. As for one of the reasons, he puts, "... if your gift economy is in contact with or intertwined with an exchange economy or a command hierarchy, your reputation may spill over and earn you higher status there[24]." It seems that his description implicitly but exactly refers to the *signaling incentives*.

2.3.2 Economics of Science: It is noticeable that GNU developers view OSS as scientific knowledge to be shared among mankind [25]. Since Arrow [26] discussed properties of knowledge that make information a public good, a number of economists has also commented on the public nature of knowledge. Stephan [27] acknowledges that competitive markets provide poor incentives for the production of a public good, because providers cannot appropriate the benefits derived from use. This is quite understandable as we have already discussed private investment theory. She argues, instead, that a non-market reward system has evolved in science that provides incentives for scientists to behave in socially responsible way [27]. As components of the reward structure of science, she proposed *recognition*, *financial remuneration* and *the satisfaction* derived from solving the puzzle. The recognition has varied forms such as eponym, prizes and publications. The financial remuneration has two major forms: ordinary

institutional compensations and extra-institutional rewards such as prize money, speaking and consulting fees, and loyalties, stocks or stock options from patents.

However, it is worth noting here that "the more a scientist's work is used, the larger is the scientist's reputation, and the larger are the financial rewards[27]." It is also noticeable that the role played by counts of publications and citations being a proxy of reputation in determining raises and promotions at universities is evident from a few empirical works [28], [29].

2.3.3 Learning Perspective: Based on the *theory of learning*, Ye and Kishida [18] argue that learning itself is one of the major motivational forces that attract software developers and users to participate in OSS development projects and to become members of OSS communities. Accepting several dyadic views of motivation in psychology literature (e.g., [12], [30]), the authors assume that factors affect motivation are both *intrinsic* (cognitive) and *extrinsic* (social)⁵. And they propose that learning from the participation drives developers to get involved in OSS projects by providing participants with the intrinsic satisfaction and extrinsic rewards at the same time.

Result from survey to OSS developers supports this "benefit-from-learning" perspective, showing that 92.8% of respondents mentioned "increased personal knowledge base" as the most important benefit of participation [31]. Apache Usernet help information providers also reported to have their effort rewarded via learning they gain scanning the questions and answers posted by others [14].

However, viewing through the lenses of human capital theory and signaling theory, learning (and the knowledge acquired from learning) can be said to result in enlarging a programmer's human capital. There may not be any difference in nature between knowledge acquired from schooling or OJT and knowledge acquired from learning-by-doing in OSS communities. Acquired and thus enlarged knowledge then plays a role as a signal for employers; hence the programmer will get a chance of better job or wage increase in future. Therefore, while learning may play a role as a vehicle to offer intrinsic and extrinsic motivation for a programmer, it may play a role as a signal for his current and potential employers as well.

2.3.4 Functional Needs: Raymond [24] argues that "every good work of software starts by scratching a developer's personal itch," and that project participants may directly benefit from the software code they develop because they intend to use it themselves. It is quite true that many OSS projects were

⁵ The distinction of behavioral motivations between *intrinsic motive* and *extrinsic rewards* has been broadly accepted in psychology literature since Edward Deci conceptualized the notion in 1975. Intrinsically motivated activities are ones for which there is no apparent reward except the activity itself, and these activities are ends in themselves rather than means to an ends. He argues that intrinsic motivation is based in the human need to be *competent* and *self-determining* in relation to the environment, and that it develops into specific motives such as achievement, self-actualization, etc. [30]. In contrast, external rewards originate from the environment and include direct or indirect monetary compensation and others' recognition [12]. Further discussion follows in the "psychological motivation theory" section in this paper.

initiated because a programmer had a personal need for some specific function or software. In other words, a programmer may decide to arise to satisfy his demand for which there is no supply; the economic rationale here referred to as “self-production [3].”

For example, what made Richard Stallman, the founder of Free Software Foundation, to drive the idea of free software was his necessity to modify the software of a Xerox photocopier for his personal convenience. Similarly, Linus Torvalds initiated the Linux kernel project because he needed the UNIX style operating system for his PC. Old wisdom that necessity is the mother of creation indeed works here. The fact that the members of an OSS community are not only developers but also users makes it possible for them to create exactly what they want without requiring a manufacturer to act as an agent [6], [32]. A survey shows that the functional, personal or pragmatic necessity is the strongest motivation for programmers to keep participating in OSS projects [31]. The existence of personal needs for new or improved software shows that participants of OSS projects act rationally after their own self-interest.

However, there exist counter-examples for this argument. For neither Kimball nor Mattis, who started the GIMP project, was there a functional need for graphic arts [18]. They did not start the project due to their own necessity. It should be noted that it is not true that all programmers do not initiate or participate for their personal needs. A survey in OSS projects also supports the counter-argument. OSS participants replied that, among many other motivation factors to participate in OSS projects, the personal need factor has relatively less importance [12].

2.3.5 Social Exchange Theory: One of the frequently referred but seemingly misused concepts from the altruistic view is gift-giving practice. Vaguely referring to the work by Mauss [33], Raymond [24] proposes an idea of a gift culture. Gift culture is based on *gift economy* which rules hackerdom, as opposed to *exchange economy* which has predominated in our society. It is an adaptation not to scarcity but to abundance, and can be observed among aboriginal cultures living in ecozones with mild climates and abundant food, as well as among the very wealthy and in show business in modern society [24]. In gift economy, help and information are offered without expectation of direct and immediate reciprocation.

Interactions in an online community consist of a gift economy [34]. However, the fact that gift-giver does not expect any return-backs does not exactly mean that he gives gifts from his altruistic generosity. In this sense, though Raymond catches some fundamental and important aspects of the cultural logic of gift-giving and sharing practices, “he does not really dig into the theoretical foundations that lead to these conclusions [35].”

There are two theoretical approaches for gift-giving: *anthropological elementarism* and *political economy* [36]. The anthropological elementarism approach, which discussed by Mauss [33], argues that the essential features of gift transactions are the obligation to give, the obligation to receive, and the obligation to reciprocate in some way for gifts received. On the other hand, political economy approach sees gift-giving as a process of exchange through which individuals rationally

pursue their self-interest. Seeing from the viewpoint of *social exchange theory*, the generosity that we observe in gift-giving is only an *apparent altruism*; in reality, giving to others is motivated by the expectation of some *rewards*, no matter whether the rewards are direct such as power over others or indirect such as social approval [37]. In any sense, it is worth noting that both theoretical approaches for gift-giving assert that the gift-giving is not from pure generosity or altruism.

Furthermore, Raymond later notes that, compared with the context in exchange economy in which social status of an individual is primarily determined by having control of scarce things to use or trade, “in gift economy, social status is determined not by what you control but by *what you give away* [24] (emphasis in original).” He further suggests that the abundance in the society of OSS in terms of disk space, network bandwidth and computing power creates a situation in which the only available measure of competitive success of an individual is reputation among one’s peers.

Therefore, what a gift-giver expects from his gift-giving is not a sense of satisfaction from altruistic give-away. On the contrary, what motivates him to give away gifts to others is *social status, reputation, or rewards* which he may obtain from his gift-giving.

2.3.6 Psychological Motivation Theory: One of the first scholars who focused upon individual psychological motivation is Abraham Maslow. He identifies a five-level hierarchy of human needs which ranges from physiological needs to the need for self-actualization at the topmost [38]. Raymond [24] draws this view to explain the motivation of OSS programmers. He puts that “on this view, the joy of hacking is a self-actualization or transcendence need which will not be consistently expressed until lower-level needs (including those for physical security and for belongingness or peer esteem) have been at least minimally satisfied [24].” Thus, programmers may write codes *just for fun* [39], and feel competence, satisfaction, enjoyment and fulfillment by solving interesting problems and writing codes. What motivate programmers to participate in OSS projects are these hedonistic feelings rooted in intrinsic individual psychology.

In order to identify potential factors that lead programmers to participate in OSS development projects, Hars and Ou [12] suggest a framework which makes a distinction between motivations which are rooted in the psychology of the *individual (internal factors)* and *external factors (reward)* which originates from the environment. The authors state that similar distinctions have been emphasized in motivation literature such as intrinsic motivation and external rewards [30], three functional factors [40], and social motivation, collective motivation and reward motivation [41]. Under *internal factors*, they conceptualize intrinsic motivations with self-determination, altruism and community identity. With respect to non-monetary *external rewards*, they make distinction between indirect rewards, including human capital, self-marketing, and peer recognition, and direct rewards from the software they develop, and labeled them *future rewards* and *personal needs*, respectively. Following a web-based email survey targeting OSS participants, however, they conclude that external rewards have greater weight than internal factors [12].

2.3.7 Collective Action Theory: One of the distinctions in OSS development projects is that OSS is developed by the Internet-based communities of programmers. A number of programmers volunteer to develop software that they find interesting. In other words, the production of OSS depends on voluntary contributions from a large number of programmers. Collective actions are operated and managed in voluntarily organized communities in order to pursue their common goals. At first sight, it would be likely to be expected that if a group of people have a common interest, they will naturally get together and work for the common goal of the community. However, Olson [10] states that this is generally not the case:

But it is *not* in fact true that the idea that groups will act in their self-interest follows logically from the premise of rational and self-interested behavior. It does *not* follow, because all of the individuals in a group would gain if they achieved their group objective, that they would act to achieve that objective, even if they were all rational and self-interested. Indeed, unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, *rational, self-interested individuals will not act to achieve their common or group interests* [10, p.2: emphasis in original].

Groups composed of either altruistic individuals or irrational individuals may sometimes act for their common or group interests. However, it is worth noting that, in general, no group or organization can support itself by voluntary contributions “without providing some sanction or some attraction distinct from the public good itself, that will lead individuals to help bear the burdens of maintaining the organization [10].”

In addition, because the goal or the purpose is common to the group, no member of the group can be excluded from the benefit brought by its achievement which is called a *collective*, a *common*, or a *public* good. As discussed previously, OSS is a public good which is nonexcludable and nonrival in nature. Anyone can download a copy of OSS for free, which means it is truly nonexcludable. And it can be replicated infinitely at no cost, which means it is truly nonrival.

However, because of its nonexcludable character, there comes the problem of *free-riding* on the efforts of others by enjoying a public good without contributing to its production. For example, all workers in a workplace benefit from salary increase by a strike no matter whether they have or have not participated in the strike. In the same vein, also in the case of OSS, there exists a strong possibility of free-riding; anyone can benefit from OSS no matter whether he has contributed to the project. It is suggested that the free-riding dilemma can be resolved in two ways [42]. In small and moderate-sized groups, it can be resolved through strategic interaction, i.e. *reciprocity* that says ‘if you cooperate, then I will too.’ In larger groups, collective action requires *selective incentives* such as laws or social norms that punish defectors or reward cooperation.

2.3.8 Private-Collective Model: Von Hippel and von Krogh [6] take notice on the fact that OSS development practice contains elements of both the private investment and the collective action. At first, they criticize that the OSS development practice has deviations from both the theories of private investment and collective action. According to them, OSS development practice involves two major deviations from the private investment theory; (1) users rather than manufacturers are the typical innovators, and (2) innovators freely reveal the proprietary good that they have developed at their private expense. Next, they argue that OSS development practice is far from the collective action practice as well, with respect to (1) recruiting and (2) motivating which have been emphasized as solutions to free-riding dilemma.

And then, by eliminating basic assumptions in both theories, they propose *private-collective model*. First, the model eliminates the assumption in private investment theory that free revealing of innovations will result in a loss of private profit for the innovators thus they will not volunteer to take part in. Instead, the model proposes that under common conditions free revealing of proprietary innovations may not represent a loss of profit to innovators, or under some conditions free revealing may result in a gain of profits. For example, free revealing can increase diffusion of innovation and so increase innovators’ innovation-related profits through network effects.

Next, the model eliminates the assumption in collective action theory that a free-rider will be able to obtain benefits from the completed public good that are equal to those that a contributor can obtain. Instead, the model proposes that contributors can inherently obtain private benefits which are available only to contributors and not to free-riders and represent a form of *selective incentives*. For example, outputs from the problem-solving process such as technical knowledge and enjoyment are the inherent private benefits which are only available to contributors but not to free-riders.

In this context, the authors suggest that OSS development is an exemplar of a compound private-collective model that contains elements of both the private investment theory and the collective action theory.

2.3.9 Extended Klandermans’ Model: Klandermans [44] established a model that explains motivation of those who participate in social movements, combining *expectancy-value theory* and *collective action theory*. The expectancy-value theory posits that the motivation for a certain action is a function of the expectation that it will yield certain outcomes and the values of those outcomes [43]. According to the theory, individual decisions to participate in a social movement are based on perceived costs and benefits of participation [44]. Therefore, rational individuals will not participate in the production of a collective good unless selective incentives motivate them to do so [10]. Thus, in applying the expectancy-value theory to the production of a collective good, Klandermans [44] distinguishes three different motives for social movement participants, and argues that each of three motives originates from a different type of expected costs and benefits: (1) the collective motive, (2) the social motive, and (3) the reward motive [45].

First, the *collective motive* derives from the collective goals of the movement, and is conceptualized as a multiplicative function of the subjective value of the collective goals for the potential participator and of the subjective expectation that these goals will be reached. Thus, the higher a person values its goals and the more likely the person perceives the attainment of these goals, the higher the motivation to participate and contribute to a social movement will be.

Second, the *social motive* derives from the expected reactions of significant others, such as spouse, colleagues or friends, to the individual's participation. It is also expressed as a multiplicative function of the subjective (positive or negative) quality of expected reactions of others and the personal importance of these reactions. The more positive the expected reactions of significant others are and the higher the perceived importance of these reactions, the higher the motivation to contribute to a movement will be.

Finally, the *reward motive* results from other expected costs and benefits such as investment of money or time. It is also conceptualized as a multiplicative function of value and expectancy components. It is assumed that the higher and the more likely the expected gains are perceived, the higher the motivation to contribute to a movement will be. All three motives are assumed to contribute to the willingness of a person to participate in collective action organized by the social movement.

From a psychological point of view, social movements are defined as "effort(s) by a large number of people to solve collectively a problem that they feel they have in common [46]." Though OSS development projects may not be typical social movements, it can be argued that some of the political and social goals of some OSS development communities can be understood as collective efforts to solve a common problem of participants. For example, the GNU project, one of the oldest communities in cyberspace, has developed into the *Free Software Foundation*, symbolized its philosophy as *Free Software Movement*. Eventually, the community did not only develop GNU kernel software but also tried to disseminate its philosophy to the public via various activities. And, it is well known that a strong anti-proprietary software mood and in effect an anti-Microsoft mood are shared within most OSS communities, which has been conceptualized as a part of the *hacker culture*. Also, the characteristic of voluntary participation in OSS development projects is an important feature similar to those of various social movements. Therefore, it seems to be highly likely to assume that the motives of those who contribute to OSS projects are similar to those of participants in social movements.

Hertel and his colleagues [47] explore the motives of contributors to the Linux kernel project by combining two theoretical models: *Klandermans' Model* and *motivational process model in small teams*. In order to develop their theoretical framework, the authors assume that the underlying motives of contributors to OSS development projects are similar to those of participants in social movements, and that a number of subgroups exist in an OSS development project and the teamwork exists in the subgroups. And, following the argument that identification with more specific subgroups is a better predictor of willingness to contribute to the social

movement than identification with the movement as a whole [45], they extended Klandermans' model to include four motivational components: *collective motives*, *norm-oriented motives*, *reward motives*, and *identification processes*. Then they conducted a web-based questionnaire survey with Linux users and developers in the Linux kernel community.

According to their analyses, the main motivational factors are (1) a more general identification factor as a Linux user, (2) a more specific identification factor as a Linux developer or with a Linux subsystem, (3) pragmatic motives related to the improvement of one's own software and career advantages, (4) norm-oriented motives related to reactions of relevant others, (5) social and political motives related to supporting independent software and networking within the Linux community, (6) hedonistic motives such as pure enjoyment of programming, and (7) motivational obstacles related to time losses due to Linux-related activities. The result also shows that contributors' activities are particularly determined by three factors: (1) their subjective evaluation of subsystem goals, (2) the perceived importance of their own contributions for subsystem, and (3) the perceived personal ability to accomplish the tasks.

3. A COMPREHENSIVE FRAMEWORK

We have examined a number of theoretical perspectives that are invited, compared, and combined in order to better understand what makes programmers motivated to participate in OSS projects. For the purpose of integrated and comprehensive understanding, we formulate a holistic three-axis framework according to the differences in the presumptions in human behavior, the types of rewards for individuals, and the level of perceived utilities: (1) self-interested drive and altruistic drive, (2) direct, indirect, and non-financial rewards, and (3) individual utilities and social utilities.

The first difference is laid in the underlying presumption on the drives of human behavior; one is the self-interested drive and the other the altruistic drive. In conventional economics, it is a basic assumption that the self-interested incentive drives one's economic actions. Viewing from this point, a rational man would not act unless the action produces his private returns, or he would choose to free-ride if he could. *Private investment theory*, *collective action theory*, *private-collective model* and *labor economics* including *human capital theory* and *signaling theory* are, either explicitly or implicitly, based on this self-interest driven human behavior presumption.

Economics of science deals with the non-market reward structure which provides scientists with incentives to behave in socially responsible way, assuming that scientists will behave in self-interested way if it were not for the non-market reward structure. *Social exchange theory* also bases upon this presumption, positing that the gift-giving is out of expectation of rewards. *Psychological motivation theory* addresses that people act on psychological motivations (i.e., intrinsic motive and/or extrinsic rewards) to get their satisfactions. Actually, it is not clearly manifested in psychological motivation theory whether the motivation is driven by self-interest. However, since it focuses on individual private satisfaction rather than

that of communities or society, the psychological motivation theory can be said to assume individual's self-interest being the main drive of human behavior. *Learning* is considered as a medium through which one can get personal psychological satisfaction, and the *functional needs* perspective focuses more on personal needs per se.

In contrast, it has been also argued that human behavior is driven by altruistic motivation rather than by self-interested motivation. *Kin Selection altruism* and *communities of practice theory* support the altruistic view and propose that altruistic feeling of contribution to community or society drives people to participate in communities. On the other hand, *Extended Klandermans' model* accepts both ambivalent presumptions. Among the subdivided motives in the models, *reward motive* and *social motive* can be considered as self-interested incentives while *collective motive* can be referred to as an altruistic incentive.

The second distinction is made from the forms of expected rewards: direct financial returns, indirect financial returns and non-financial rewards. It is the main argument of *private investment theory* that people expect direct monetary returns from their private investment. In most cases with private investment theory, private investment results in creation of private goods and then financial returns from them are guaranteed in relatively short-term period through the market system, i.e. via patents and copyrights. Since OSS is a public good from which financial returns are rarely expected, however, it is argued that programmers do not contribute out of expectation of direct financial returns.

Table 1. Characteristics of three types of rewards

	Direct Financial Returns	Indirect Financial Returns	Non-Financial Rewards
Nature of Products	Private Goods	Public Goods	Public Goods
Incentive Mechanism	Market System	Market and/or Non-market System	Non-market System
Perceived Utilities	To Individuals	To Individuals	To individuals and/or To Society
Functional Motivations	Direct or short-term Financial Returns <ul style="list-style-type: none"> • patents/ copyrights 	Indirect or long-term Financial returns <ul style="list-style-type: none"> • wage increase • job offer • reputation • knowledge acquiring • private functional needs 	Psychological Satisfaction <ul style="list-style-type: none"> ■ Micro Level <ul style="list-style-type: none"> • sense of belonging • sense of esteem • fun/enjoyment (self-actualization) ■ Macro Level <ul style="list-style-type: none"> • moral obligation (reciprocity) • contribution to community/society

However, even though she does not expect direct financial returns, a programmer may expect (or perceive) long-term or indirect financial returns from her contribution. In *human capital theory*, *signaling theory* and *economics of science*, it is straightforwardly explained that a prominent contributor or an eminent scientist gets better jobs and wage increases, which can be referred to as long-term or indirect financial returns. As

well, *rewards* that a gift-giver obtains from gift-giving may lead her to get higher social status or higher reputation, which will provide her with financial returns in future. Also, the *extrinsic rewards* in psychology literature include direct or indirect financial returns. A programmer may participate in OSS projects in order to develop software which needs to be customized to perform specific functions necessary for his job. However, if she would not participate in the development project, the alternative should be either to buy the similar proprietary software from the market or to pay someone to create it. Thus, because she could save money, it can be said that the programmer gets indirect financial benefits from her participating in OSS projects.

From his contribution or participation, however, a programmer may feel, expect or pursue non-financial rewards rather than (or, at the same time) financial returns. The non-financial rewards are drawn from psychological satisfaction. He may participate in OSS development communities and contribute to projects in order to feel the sense of belongingness, the sense of esteem, or the sense of self-actualization. Especially, a sense of self-actualization such as fun, enjoyment and satisfaction derived from solving puzzles is proposed to have strong motivational effects. Also, he may feel satisfaction from the feeling that he fulfills his social responsibility of reciprocation or contribution to the communities or society.

It is noticeable that, however, *learning* is proposed to provide both non-financial rewards (i.e., intrinsic satisfaction) and financial returns (i.e., extrinsic rewards). It should be also noted that *Klandermans' model* takes both financial and non-financial returns for the expected rewards; while collective motive and social motive refer to non-financial rewards, reward motive refers to financial returns. *Private-collective theory* also implicitly takes both financial and non-financial returns, positing profits, technical knowledge and enjoyment are possible benefits for contributors. Table 1 classifies and summarizes the characteristics of rewards and motivations.

The last distinction is drawn from the level of perceived utilities. The *community of practice theory*, reciprocity in *collective action theory* and the collective motive in *Klandermans' model* take notice of contributors' perception that they contribute to the enhancement of utilities of communities or society to which they belong. On the contrary, other perspectives assert that contributors perceive that their contributions satisfy their private utilities.

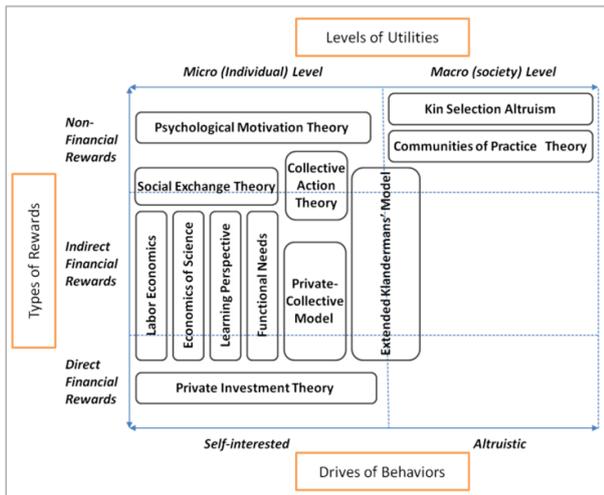


Fig. 1. A comprehensive theoretical framework

In Fig. 1, the perspectives discussed above are arranged on a holistic three-axis graph according to the differences in presumptions in human behavior (i.e., self-interested and altruistic), types of rewards for individuals (i.e., direct financial, indirect financial, and non-financial), and the levels of perceived utilities (i.e., micro- and macro-level).

To summarize, from participation in and contribution to OSS development communities, people expect some kinds of rewards: financial returns and/or non-financial rewards. Since OSS is a public good, however, people are well aware that they may not expect direct financial returns; instead, they expect indirect financial returns and/or non-financial rewards. *Rewards* [37], *reputation* or *social status* [24], *recognition* [27] and *functional needs* [31] seem to be closely related to *selective incentives* [6], [10], *reward motive* [44] and the *signaling incentive* [20] with respect to the possible (immediate or future) benefits derived from them. In other words, knowledge, reward, reputation, social status, and recognition, which are acquired through participation or contribution, may eventually generate indirect or long-term financial benefits. For example, “a desire for a higher status within the gift culture may be as strong of an incentive to contribute as career concern incentives [23].” The case of Linus Torvalds, the developer of Linux, provides a good example. He was granted stock options from Red Hat and VA Linux in 1999, which were just thank-you gifts from CEOs of the companies for his creation and valued at \$1 million and \$20 million respectively when the companies went public. He was also provided with a job from Transmeta, a Linux related company [48]. This story is well known among programmers and may have aroused them to seek similar gains.

4. DISCUSSION AND CONCLUSION

4.1 Discussion

In this paper, by integrating diverse perspectives from economics, sociology, political science, anthropology, psychology and management, we have tried to integrate various explanations for the motivations of people who would participate in OSS development projects. As shown in previous

parts, OSS is a very complicated phenomenon that relates to economics, technology, human behaviors, culture, and society. So are the motivations of contributors and participants. Thus, to claim that the motivations of volunteers can be understood by any one perspective would be not exactly true or possible either. While one theory appears to be good enough to understand some aspects of motivations, other theories may be more persuasive to explain other aspects. However, the theories discussed above seem to be complementary rather than competitive or mutually exclusive. It is quite true that a person acts by multiple motivations to satisfy multiple expectations. The real motivations may be even hidden under his superficial perception. Furthermore, it is important to point out that some of those different explanations are overlapping. Thus, in order to better understand the motivations of OSS participants, viewing from different viewpoints and developing integrative analytical angles, which are the purpose of this paper, are needed further.

As theoretical studies are, empirical studies on OSS phenomenon are fairly recent, and most of them adopt questionnaire surveys and interviews with OSS participants. Only a few have sought to verify explicitly theoretical propositions on the motivation of OSS participants. Key empirical studies and their findings are listed in Table 2.

Table 2. Key empirical studies on OSS participants' motivations

Study	Survey field	Theoretical approach	Empirical findings on motivation factors
Wasko and Faraj [13]	Usenet newsgroups	Communities of practice theory	<ul style="list-style-type: none"> Community interest (41.9%) Tangible returns (21.5%) Intangible returns (19.9%)
Hars and Ou [12]	OSS communities	Psychological motivation theory	<ul style="list-style-type: none"> External rewards > Internal rewards
Hann et al. [23]	Apache community	Human capital theory and signaling theory	<ul style="list-style-type: none"> Contributions per se do not increase wages, but higher status leads to higher wages.
Lakhani et al. [31]	OSS communities	-	<ul style="list-style-type: none"> Work or non-work functionality (63.5%) Intellectually stimulating (44.9%) Improves skills (41.3%)
Hertel et al. [47]	Linux kernel community	Social psychology	<ul style="list-style-type: none"> General identification (Linux user) Specific identification (developer/subsystem) Norm-oriented motives Pragmatic motives Social/political motives Hedonistic motives Time loss
Lakhani and von Hippel [14]	Apache Usenet help forum	-	<ul style="list-style-type: none"> Generalized reciprocity Identification to the community Intrinsic rewards

4.2 Future Research Agenda

Probably more considerable research agenda could be found in empirical approaches that reflects diverse theoretical aspects. For example, as Franke and von Hippel [49] point out that there exists high heterogeneity of need among OSS users, it should be noted that lots of programmers with diverse needs work together in a community in order to develop OSS. Though they collectively pursue their common goals of

developing OSS, it could be deduced that programmers with different needs may have somewhat different motivations for participation. The motivation of the programmer who works in spare time as his hobby, for instance, might differ from that of the programmer who is paid for his work.

While many researchers have considered OSS participants as members of a homogenous group, several other researchers have attempted to take notice of the diversity in participants' traits. In the studies, participants were classified into several categories according to their distinct features, and it was found that there exist differences in extents of motivation functions between the categorized participants [12], [14], [18], [31].

However, those findings, and classification as well, appear to be sort of plain descriptive summary from survey analyses, possessing weak theoretical basis and little cogent explanation. Thus, in sum, developing more refined criteria to classify participants, along with theoretical propositions to be verified, and providing rich and cogent interpretation of the empirical results would be more useful for better understanding of the motivations to participate in OSS development projects.

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