

Working for Free? – Motivations of Participating in Open Source Projects

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Abstract

The success of the Linux operating system has demonstrated the viability of an alternative form of software development – open source software – that challenges traditional assumptions about software markets. Understanding what drives open source developers to participate in open source projects is crucial for assessing the impact of open source software. This article identifies two broad types of motivations that account for their participation in open source projects. The first category includes internal factors such as intrinsic motivation and altruism, and the second category focuses on external rewards such as expected future returns and personal needs. This article also reports the results of a survey administered to open source programmers.

1. Introduction

The success of Linux, an open source operating system, is currently receiving much attention by software developers and software users alike. Linux is touted as highly stable and reliable [13]. It has steadily increased its market share and has led to a consolidation among UNIX operating systems. To counter the threat from open source software, some commercial vendors have already taken extreme measures. Sun, for example, has switched most of its Solaris operating system to an open-source license, eliminating a significant revenue stream. Furthermore, Linux is not an isolated phenomenon. Open source software has become a viable alternative in many other software markets.

The open source development model fundamentally changes the approaches and economics of traditional software development. Typically, open source software is developed by an internet-based community of programmers. Participation is voluntary and participants do not receive direct compensation for their work. In addition, the full source code is made available to the public. Developers also devolve most property rights to

the public, including the right to use, to redistribute and to modify the software free of charge. This is a direct challenge to the established assumptions about software markets that threatens the position of commercial software vendors.

The open source phenomenon raises many interesting questions. Its proponents regard it as a paradigmatic change where the economics of private goods built on the scarcity of resources are replaced by the economics of public goods where scarcity is not an issue. Critics argue that open source software will always be relegated to niche areas, that it cannot compete with their commercial opponents in terms of product stability and reliability [15], and that open source projects lack the capability to innovate. As commercial companies are looking for adequate responses and legislators discussing its implications on social welfare, they need to understand one fundamental question. That is, in the absence of direct compensations what is it that motivates the participants? Is the image correct that open source developers are highly altruistic people who want to advance the good cause or are there other explanations?

Answering this question requires input from the open source community. In the following, we will first discuss the history and importance of the open source phenomenon. A categorization of the motivations of the open source programmers will then be presented, and the results from a survey administered to the participants in various open source projects be reported. The underlying theories will be discussed together with the results from the survey.

History of open source software

The origin of open source software can be traced back to the 50s and 60s when software was sold together with hardware, and macros and utilities were freely exchanged in certain user forums. In the 80s, as software was increasingly commercialized, Richard Stallmann, then a researcher at MIT founded the Free Software Foundation (FSF) that provided a conceptual foundation for open source software. While his 'GNU manifesto' [23] was

criticized for ideological baggage, his ideas are the basis of today's open source movement. Stallmann began a protracted community development effort called GNU, aiming to develop a free UNIX-like operating system. Although this effort was not successful as intended, it led to the creation of an open source infrastructure with tools and utilities, on which the subsequent open source projects such as Linux could build. Today's Linux operating system is a mixture of software developed in the GNU project, a Linux kernel and many additional components.

Table 1: Open Source Timeline [10], [20], [5], [8], [22]

Year	Event
1950s and 1960s	Software source code is distributed without restrictions in IBM and DEC user groups, ACM's Algorithms Section etc.
1969	Ken Thompson writes the first version of UNIX. Its source code is distributed freely throughout the seventies.
1978	Donald Knuth (Stanford) publishes TEX as free software
1979	Following AT&T's announcement to commercialize UNIX, UC Berkeley begins with the creation of its own version of UNIX, BSD (Berkeley Software Distribution). Eric Allmann, a student at UC Berkely develops a program that routes messages between computers over ARPANET. It later evolves into Sendmail.
1983	Stallmann publishes GNU Manifesto calling for free software, and establishes Free Software Foundation.
1986	Larry Wall creates Perl (Practical Extraction and Report Language), a versatile programming language used for writing CGI (Common Gateway Interface) scripts.
1987	Developer Andrew Tanenbaum releases Minix, a version of UNIX for the PC, Mac, Amiga, and Atari ST. It comes with complete source code.
1991	Linus Torvalds publishes version 0.02 of a new UNIX variant that he calls Linux in a Minix newsgroup.
1993	FreeBSD 1.0 is released. Based on BSD Unix, FreeBSD includes networking, virtual memory, task switching, and large filenames. Ian Murdock creates a new linux distribution called Debian Linux.
1994	Marc Ewing forms Red Hat Linux. It quickly becomes the leading Linux distributor. Bryan Sparks founds Caldera with backing by former Novell CEO Ray Noorda.
1995	The Apache Group builds a new Web server, Apache, based on the National Center for Supercomputing Applications' (NCSA's) HTTPd 1.3 and a series of patch files. It has become the dominant HTTP server today.
1998	Netscape not only gives away Communicator 5.0 (Mozilla) but also releases its source code.

	Major software vendors, including Computer Associates, Corel, IBM, Informix, Interbase, Oracle, and Sybase, announce plans to port their products to Linux. Sun announces plans to release the source code for Java 2 to developers.
1999	Number of Linux users estimated at 7.5 Million.
2000	More software companies such as Novell and Real release versions of their products which run on Linux.

2. Sources of motivations

Much research has focused on what motivates people. Maslow [16] identified five levels of needs that drive human activities. They range from physiological needs to the need for self-actualization. Deci [6] emphasized the distinction between internal, psychological factors which he called 'intrinsic motivation' and external factors which he called 'external rewards'. Intrinsic motivation includes the desire of feeling competence and self-determination. External rewards include factors such as direct or indirect monetary compensation, and other's recognition as well. The distinction between motivation and external rewards is also emphasized by Herzberg [11], who views motivation as a function of three factors: ability of the individual over potential, ability over ability and reinforcement behavior. Similar distinctions are also made by Klandermans [14] who distinguishes between social motivations, collective motivations and reward motivations.

In the following the distinction between motivations which are rooted in the psychology of the individual (internal factors) and external factors (rewards) which originate from the environment will be used as the basis for identifying potential factors that lead programmers to participate in open source development.

2.1. Internal factors

Proponents of open source development emphasize the selfless and motivated nature of open source participants. They argue that open source programmers are not motivated by monetary incentives but by their own hobbies and preferences instead, or that they receive rewards from increasing the welfare of others. Such motivations that are ultimately rooted within the individual himself are grouped under internal factors.

2.1.1. Intrinsic motivation

There are certain activities and behaviors that people like to perform naturally, e.g., playing games or collecting coins. Deci [6] describes this kind of motivation as arising from a person's inborn need for feeling competent and self-determining in dealing with his environment and

labels it intrinsic motivation. This explains some of the intensity with which people pursue their hobbies. Maslow [16] also points out these needs, although he groups them differently. He distinguishes between the need for self-actualization and esteem needs. The latter is the ‘desire for a stable, firmly based, usually high evaluation of themselves’ [16] (p. 21). He divides esteem needs into two subsets, one of which is more internally focused while the other includes the desires for recognition, fame and reputation, which will be discussed in the section on external factors.

Applied to the open source context, this category describes programmers as being motivated by the feeling of competence, satisfaction and fulfillment that arises from writing programs. One of the respondents, for example, described his motivation as:

“Innate desire to code, and code, and code until the day I die.”

Intrinsically motivated goals as autonomous goals have been suggested to be associated with most effortful behaviors comparing to controlled personal goals (non-intrinsically motivated goals), and will thus lead to higher possibility of goal attainment [21]. Since all behaviors can be regarded as goals [2], so can the behavior of participating in open source projects. It is therefore expected that open source programmers with intrinsic motivations will spend more time and effort in open source projects.

If the open source movement were solely based on this motivation, a disadvantage over commercial development might result. The motivation of the participants is not necessarily linked to the needs of the users. In cases where the community of users and the community of programmers are not identical, open source software would have an inherent problem of incorporating user needs.

2.1.2. Altruism

Another variant of intrinsic motivation is altruism, where a person seeks to increase the welfare of others. Altruism has been regarded as a personal disposition opposite to selfishness. For example, it is defined as “doing something for another at some cost to oneself” [17] (p. 5). Open source programmers provide something for others (writing programs that have open source codes) at their own costs (time, energy, opportunity costs), and therefore belong to this category. As other altruistic behaviors, we expect altruism to be an important drive that motivates the open source programmers to participate in open source projects. Altruism is widely regarded as being associated with positive norm and – following the Theory of Reasoned Action [1] – should have a positive influence on the level of participation in open source projects.

2.1.3. Community identification

Another internal motivation is a variant of altruism, here labeled community identification. It corresponds to Maslows’ needs of belonging and love. Programmers may identify themselves as part of the open source community and align their goals with those of the community. They 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” by social psychological researchers [12]. Programmers with this variant of intrinsic motivation will be motivated to participate in open source projects and help their kinship partners.

2.2. External rewards

Open source programmers may also be motivated by external factors. While the vast majority of open source programmers are not compensated for their contributions directly, they may receive indirect rewards by increasing their marketability and skill base or selling related products and services. Another form of external rewards may be related to the fruits of the software. They will be labeled “future rewards” and “personal needs” respectively.

2.2.1. Future rewards

Open source programmers may view their participation as an investment from which they expect future returns [7] (p. 13). Such returns will be elaborated below. The economics of such investments are well understood. The question that remains specific to the open source community is the nature of the returns. Three different categories of returns need to be distinguished:

Revenues from related products and services. Open source software provides many opportunities for selling related products and services. In the case of Linux, individuals and companies like RedHat have begun to offer commercial consulting, training, distribution, support, and implementation services. The open source community endorses such income-generating activities, although the boundary is sometimes fuzzy. However, this motivation has an inherent conflict: improving the open source software may reduce the potential for selling its related services or products such as maintenance and trouble-shooting etc.

Human capital. Open source programmers may also participate in open source projects to expand their skill base. Personal skills, capabilities and knowledge are deemed as a special form of capital, human capital, by economists. A number of ways are available to increase one’s human capital level, for example, education, training, learning, and practicing etc. [3], leading to better job opportunities, higher salaries and more fulfilling jobs.

The 'open' source codes and freedom to choose tasks enable the open source programmers to select the learning experiences that meet their demand and interests. It also enables those entry-level programmers like college students to participate in realistic projects at a very early stage.

Self-marketing. Programmers may also regard working for open source software as an effective way to demonstrate their capability and skillfulness in programming. Claims of competence in programming can be well reinforced by the achievements in open source projects. Participating in open source projects therefore can be a good advertising channel to publicize one's skillfulness and capabilities. Advertisement is also associated with future returns.

This argument of self-marketing has an important implication. The larger the contribution of an individual to the open source projects, the more likely it is that the commercial software vendors will recognize the value of the individual, and the larger the incentive will be for this individual to apply his skills in a paid position. Thus the openness of open source projects may work to some extent against themselves. It may help to lure the best programmers and most productive minds away from these projects into more profitable commercial development.

Peer recognition. Peer recognition is derived from the desire for *fame* and esteem [16], which is associated with future returns. As Raymond [19] noted in his historic paper about open source software development style "The Cathedral and the Bazaar", open source software should ascribe its success considerably to its early, fast and frequent releases. Similarly, open source programmers receive rapid and constructive feedback about the quality of their composition. Feedback always has a positive effect – it shows the programmer that people are using their contribution. Thus feedback is self-reinforcing: it encourages the author to spend additional effort to perfect his code.

2.2.2. Personal needs

As the history of open source projects shows, many open source projects were initiated because a programmer had a personal need for some software. For example, the programming language PERL was created by Larry Wall when he needed to generate web pages programmatically. He found it too cumbersome to write his programs in C and therefore developed simple routines that could be reused and combined [18] (p.194). These routines were

later shared with other programmers, who also extended and refined the routines. The development of the Apache web server followed a similar pattern. In 1995, a large number of web masters were using the NCSA web server. It had many problems that the web masters circumvented by writing their own patches. Quickly, a core group of web masters formed to share their patches. They rewrote the web server to include more patches and the Apache web server was born [9]. In both cases the driving force for participating in an open source project was the personal need of a programmer (or a group of programmers) for specific software functionalities [4] (p. 159).

The existence of personal needs has important implications for open source projects. First, it shows that participants of open source projects may act rationally after their own self-interest. But if selling the software involves significant transaction costs, they will provide it for free. Second, it shows that there should be a limit to the amount of effort that a programmer may provide for free. The more complex a product is, the less dependent it is on other modules of software, so the more likely its contribution be identified and communicated, and the more likely it is that a programmer will sell his software rather than provide it for free. Some cases may already be cited. Eric Allmann, for example, the founder of Sendmail, one of the most successful email server programs, has started a company that provides an add-on product to Sendmail to simplify its configuration and administration. This is a large module useful to most adopters of Sendmail and thus can be marketed effectively. The third implication of personal need may be the most important. It shows that the interests of the users and developers are often aligned: both are interested in improving the functionality; both are willing to invest in improvements. However, traditional software houses structure their license agreements in a way that prevents customers to invest in their software by making modifications and by sharing the improvements with others. This would raise the value of the license to prospective buyers and thus increase the revenue stream or market position of the software vendor. However, because of the fear of piracy, software houses have given up considerable potential investment opportunities that customers are willing to take. From the perspective of leveraging needs in improved functionality, this category of motivation demonstrates a crucial oversight in the marketing and product evolution strategies of current software companies.

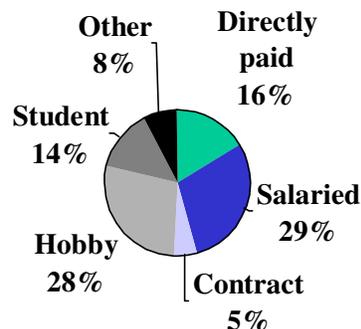
3. Empirical analysis

To understand the participation in open source projects better, it is necessary to have first-hand data from the programmers. After analyzing the potential components of motivation mentioned above, an invitation to participate in a web-based survey was sent to 389 persons involved in open source projects via email. Their email addresses were collected from open source discussion lists and news groups over the Internet. These groups included both general open source communities and specific open source project programmers' forums. The survey asked specific questions concerning the factors that impact their participation in open source projects, and also included exploratory questions about general aspects of open source software. A list of the operationalization questions is included in the appendix. The survey received 81 responses of which 2 were invalid, which leads to a response rate of 21%.

3.1. Respondent demographics

The vast majority (95%) of the respondents is male. Most are between 20 and 40 years old. Although most participants have college degrees or higher, about a quarter of them have only high school or grammar school education. Almost half of open source participants are professional programmers who earn their living as salaried or contract programmers (see figure 1). Interestingly, a significant share of the respondents (16%) is directly paid for their open source programming. Their share of reported effort is even higher: 38% of total working hours are contributed by paid open source programmers, who work for commercial companies that support the open source movement. Besides these programmers, there is a large number of professional (salaried and contract) programmers who participate voluntarily without direct compensation. The rest comprises students (14%) and people who consider programming their hobby (28%).

Programmer types



Highest degree earned

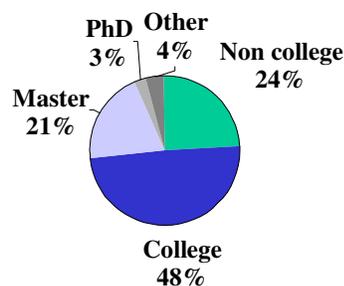
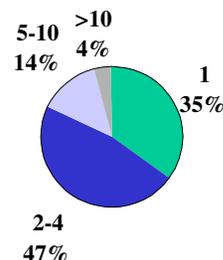


Figure 1: Respondent demographics

No. of projects



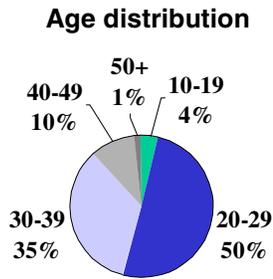


Figure 2: Participant characteristics

As Figure 2 shows, the majority of open source respondents are engaged in more than 1 project. The projects these programmers are most active in are listed in table 2. While Linux has the highest share, the table shows that there is an impressive number of less known open source projects.

3.2. Motivations

In our questionnaire, 16.5% of the participants rate high on altruism. Almost 30 percent of the respondents identify strongly with the open source community or a kin-like relationship with other open source programmers. Of all the 79 valid responses that we received, 11 (13.9%) selected “selling related products or services” when asked why they participate in open source projects. The fraction of human capital investors who aim at improving their own human capital is remarkably high. 51 out of 79 respondents (70.9%) chose “improving my programming skills” when asked why they participate in open source projects. Still, some other respondents participate in open source projects because they can improve their human capital by learning things other than programming. For example, one of them put “learn English and teamwork” when being asked the same question. In terms of self-marketing, when asked the motivation of participation questions, some respondents explicitly indicate that they participate in open source projects because “it demonstrates my abilities”, or “I can use it as a reference...” etc. More than half of the respondents (41 out of 79, 51.9%) selected “because I build a network of peers” as the reason to participate in open source projects. Similar statements made by other respondents include “hope to gain positive reputation” and “because it is a expression of personal liberty”, etc. Our expectation about programming for personal needs is confirmed by the responses like this:

“Needed the product - might as well make It Open Source.”

“[My motivation is] To develop tools I need to do my job.”

Table 2: Respondent’s primary open source projects

Multiple occur.		Single occurrences		
Linux (21)	AbiWord	Genes	LTSP	Tabindex
Midgard (4)	Analog	Gtk	MPLS for Linux	The COG Engine
Perl (3)	Cons	Hover	NetBSD	Vaxbb
GNU (3)	CPUlab	Carnage	OpenClas sroom	Wftk
PhP (3)	Debian	K2W	Qwik	WINE
Harbor Project (2)	Dents	Voyageur	Immobile	Mail
Java (2)	Eskey	Lesstif	Rasteroids	Xsu
FreeBSD (2)	FreeCiv	Libdbg	SANE	
	Gdb	Libsndfile	Smail3	
		LTPlus	Sqwebmai	l

Table 3 shows the percentages of the respondents who ranked high or very high on each of the eight motivation subcategories. In addition, it reports the correlation coefficients of the subcategories with the participants’ effort level. The table shows that open source participants rank most highly on human capital and self-determination. It also shows that the highest correlation coefficients for the external factors are selling products, self-marketing and personal need. Among the intrinsic variables, altruism correlates more strongly with effort than self-determination and community identification. The patterns differ strongly, however, when different groups of programmers are considered. Students and hobby programmers rate higher on internal motivation than the average. They are also very much concerned about human capital. However, external factors and especially human capital are not highly correlated to their effort. Students and hobby programmers seem to be more strongly motivated by altruism and community identification. The picture is different for salaried and contract programmers, who rank higher than average on self-determination and on personal need. Surprisingly, for this group of programmers, self-determination as well as peer recognition needs correlate negatively with effort. The strongest positive correlation relates to selling products.

Their level of effort, however, is most strongly correlated to the desire to sell related products and services. It is interesting to see that for this group (and for the paid developers) the need for peer recognition is negatively correlated with effort. The third group – programmers who are paid for their open source

development – differs markedly. They are stronger than average in terms of the desire to sell related products, self-marketing and personal need. The strongest correlation exists in self-marketing. Negative correlations exist with peer recognition and community identification. Thus the motivations for participating in open source projects differ greatly between different groups of participants.

The analysis of correlation coefficients suggests that external rewards are more important than the internal motivations that are so frequently advanced by proponents of the open source movement. However, the analysis of correlations has significant shortcomings as it only considers relationships between two variables. In our latest project, therefore, the interdependencies between multiple variables will be examined using factor analysis with LISREL.

Table 3: Motivations by programmer type

Motivation	All		Students & hobby programmers		Salaried & contract programmers		Programmers paid for OS development	
	Percent	Corr w. effort	Percent	Corr w. effort	Percent	Corr w. effort	Percent	Corr w. effort
1. Internal								
- Self-determination	79.7%	0.072	81.8%	-0.015	92.6%	-0.303	61.5%	0.221
- Altruism	16.5%	0.192	24.2%	0.356	11.1%	0.061	7.7%	-0.163
- Community identify.	27.8%	0.116	36.4%	0.361	18.5%	-0.130	30.8%	-0.307
2. External								
2.1 Future rewards								
- Selling products	13.9%	0.363	6.1%	0.011	3.7%	0.488	53.8%	0.304
- Human capital	88.3%	0.139	96.9%	0.080	88.5%	0.073	84.6%	0.065
- Self-marketing	36.7%	0.317	33.3%	0.206	29.6%	0.208	69.2%	0.424
- Peer recognition	43.0%	-0.021	42.4%	-0.023	48.1%	-0.145	46.2%	-0.178
2.2 Personal need	38.5%	0.304	36.4%	0.301	38.5%	0.186	38.5%	0.328

4. Conclusion

This article has shown that the motivations for participation in open source projects are more complex than expected. While internal factors such as intrinsic motivation, the joy of programming and the identification with a community play a role, external factors have greater weight. Besides, factors such as building human capital and self-marketing that promise future monetary rewards, the personal need for a software solution is another key factor that has not yet received sufficient attention. The survey also indicates that different groups of developers participate in open source projects. Hobbyists and students are the most internally motivated. Salaried and contract programmers, in contrast, seek to sell related products and services. The results show a surprisingly high number of developers who are paid for their open source development efforts. These developers are most concerned with self-marketing and fulfilling personal software needs. As a consequence, the open source movement can draw from a diverse set of motivations, a large part of which is based on external rewards. It is poised to become a strong competitor to traditional software development.

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Appendix

Questions used to operationalize each motivation categories.

- **General issues:**

1. Why do you participate in open source projects? Check all that apply.

A. Programming is fun;

- B. It is a noble cause;
- C. I can change/extend the software to fit my specific needs;
- D. Expect to sell products or services related to it;
- E. Helps me improve my programming skills;
- F. Build a network of peers;
- G. I am paid to do this job;
- H. Others.

2. I spend most of my programming time as a:

- A. Salaried programmer;
- B. Contract programmer;
- C. Hobby programmer;
- D. Student;
- E. Others.

3. Do you receive direct compensation (e.g., salary, contract) for your participation in the project?

- A. Yes;
- B. No.

(Measured at 7-point scale with extremes in the parentheses)

- **Intrinsic motivation**

1. Writing programs is fun. (strongly agree/strongly disagree)
2. I enjoy writing programs. (strongly agree/strongly disagree)
3. Programming gives me a chance to do the jobs I feel I do the best. (strongly agree/strongly disagree)
4. Participating in the project gives me a feeling of accomplishment. (strongly agree/strongly disagree)
5. Participating in the project gives me a feeling of competence. (strongly agree/strongly disagree)
6. Participating in the project gives me a feeling of effectiveness. (strongly agree/strongly disagree)
7. I rate my participation as an important activity for myself. (strongly agree/strongly disagree)

- **Extrinsic rewards:**

1. I am paid to work for the project. (strongly agree/strongly disagree)
2. I receive some form of explicit compensation (e.g., salary, contract) for participating in the project. (strongly agree/strongly disagree)
3. For me, working for the project is: (extremely profitable/not profitable at all)
4. Comparing to other programming jobs, working for the project is: (very well paid/very poorly paid)

- **Personal needs:**

1. How often do you use the software for yourself (excluding programming or testing activities)? (always/never)
2. The software is critical for my business or my work: (strongly agree/strongly disagree)

3. My participation in the open source project ensures that the software provides functionality that matches my unique and specific needs. (strongly agree/strongly disagree)
4. It is hard for commercial software to meet my ever changing needs. (strongly agree/strongly disagree)
5. Being able to fix problems with the software myself is one of the great advantages of open source software. (strongly agree/strongly disagree)

● **Future returns:**

1. Experience from the project raises my skill level of programming. (strongly agree/strongly disagree)
2. Because of my involvement in the project, I will be able to get a better job. (strongly agree/strongly disagree)
3. In one way or another I will make money from my participation in the project. (strongly agree/strongly disagree)
4. Participating in the project makes me more marketable. (strongly agree/strongly disagree)
5. I will sell products related to the project. (strongly agree/strongly disagree)
6. I will sell consulting, training, implementation or customization services related to the project. (strongly agree/strongly disagree)

● **Altruism:**

1. I don't care about money. (strongly agree/strongly disagree)
2. You can always trust an open source programmer. (strongly agree/strongly disagree)
3. Recognition from others is my greatest reward. (strongly agree/strongly disagree)
4. Open source programmers should help each other out. (strongly agree/strongly disagree)
5. I deeply enjoy helping others - even if I have to make sacrifices. (strongly agree/strongly disagree)
6. Open source programmers are a big family. (strongly agree/strongly disagree)
7. I am proud to be part of the Open Source Community. (strongly agree/strongly disagree)

● **Effort level:**

1. Actually, how often do you work for the project? (more than once a day/not at all)
2. Actually, how many hours a week do you spend in the project? (more than 60/less than 5)

● **Demographic characteristics:**

1. My gender is: (male/female)
2. The year of my birth is: (1940/.../1990)
3. My highest education degree is:
 - A. Grammar school;
 - B. High school;
 - C. Associate degree;

- D. College degree;
 - E. Master's degree;
 - F. Doctoral degree;
 - G. Others.
4. My marital status is:
 - A. Single;
 - B. Married;
 - C. Separated;
 - D. Divorced;
 - E. Widowed;
 - F. Others.
 5. My annual household income is: (up to \$10,000/.../over \$100,000)
 6. My primary occupation is:
 - A. Clerical/Administrative;
 - B. Craftsman/Craftswoman;
 - C. Educator/Full time student;
 - D. Executive/Manager;
 - E. Factory operator/Laborer;
 - F. Homemaker;
 - G. Military;
 - H. Professional/Technical;
 - I. Retired/Not working;
 - J. Sales;
 - K. Self-employed;
 - L. Service worker;
 - M. Others.