A Survey on the Importance of Some Economic Factors in the Adoption of Open Source Software

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Abstract. Economic advantages have long been used as a key factor for promoting the adoption of Open Source Software. This paper reports on an investigation about the impact of economic factors when deciding on the adoption of Open Source Software, in the framework of a survey carried out in the QualiPSo project. The results seem to indicate that economic issues may have a remarkably lower impact than commonly believed, though people with roles more directly related to economic results and working in private companies seem to give economic factors more consideration than other Open Source Software stakeholders.

1 Introduction

The usage of Open Source Software (OSS) has been continuously increasing in the last few years, mostly because of the success of a number of well-known projects. OSS products are characterized by the free availability of the source code and a number of other software artifacts. In addition, the development process of OSS is "open" too [11]. Contributions to the source base are often made by volunteers and there is no rigidly organized development process. OSS can be used directly by end users or it can be customized, modified, or integrated into other products. So, a number of different categories of OSS stakeholders exist: developers, integrators, system administrators, product managers, clearing house members, end users, etc.

Given its success, OSS is no longer viewed as an amateur kind of software development. A number of major international software players have become more and

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more interested in developing and using OSS, and they have created internal OSS development and assessment units, because they see OSS as a good opportunity to do business.

Along with ethical and technical ones, financial reasons have often been touted as very important in the adoption of OSS. The free availability of the source code has often been mentioned as one of the key factors in the introduction of OSS in industrial environment (even though it has been pointed out that OSS is not necessarily free of charge [4, 3]). The idea, at any rate, is that the adoption of OSS can basically provide value for free, to all of the above mentioned OSS stakeholders. For instance, end users may view OSS as a software product they can use to improve their own productivity; developers and integrators as a way to reduce effort and time needed to build a software product, while keeping quality at a high level and receiving support from the OSS development community; software managers as a way to reduce costs, keep schedules, and successfully deliver software products for specific customers or the general marketplace. Note that the benefits of the openness of OSS span beyond the mere financial factors. For example, end users and all stakeholders in general may benefit from the knowledge of the list of known faults.

At any rate, it has been long known that, when carrying out a fair cost-benefit analysis of OSS, it is necessary to look beyond the fact that an OSS may be free of charge. The cost of OSS, like the cost of many other products, needs to be evaluated along all of its lifecycle. One needs to ascertain or at least estimate the various kinds of costs that may be encountered during and following the adoption of OSS. OSS stakeholders may not be totally aware of these costs. For example, the customization of an OSS product to fit the specific needs of an organization may very well not be free of charge. Charging for customization is the basis of the business model of a number of software developers that use OSS as their primary software source. This business model has several analogies, like, for instance, in the case of computer printers. The computer printer itself may be bought for a relatively low price, but then the ink cartridges needed to actually utilize the printer may be quite expensive. Also, there may be costs related to switching to OSS from a previously used product. Users or developers may need to learn the features and/or structure of the OSS product they are adopting, with at least temporary loss of productivity.

All of these costs may be viewed as investments, which are supposed to yield a return at some point in the future. So, the Return on Investment (ROI) and the Total Cost of Ownership (TCO) are usually believed to be two important factors that need to be taken into account when deciding whether to adopt a specific OSS product.

Financial advantages and value, however, are not the only things that matter when adopting OSS, like any other product. A number of other concerns come into play. For instance, the possibility of receiving support, should any problems arise, is often considered a real issue in the OSS world. In this respect, OSS still bears the business stigma of its early days, when it was mostly developed by volunteer enthusiasts, who would not have any responsibilities in case of problems, nor would be legally or otherwise bound to provide any kind of support for bug fixing or adding new functionalities or perfecting and customizing existing ones. OSS stakeholders would know of no clear roadmap for the development of an OSS product, so for

instance there would be no assurance that the new version of an OSS product would still be compatible with the old ones. Even more importantly, OSS stakeholders would have no assurance that support may be available for a given OSS product, even not for free. OSS development communities may start and end without any notice, and there would be no recourse for OSS stakeholders. Thus, OSS stakeholders need to trust OSS software. As the example about support shows, the notion of trustworthiness is not simply confined to technical issues, e.g., the quality or the security of and OSS product. An OSS product is trustworthy if itself and its development and maintenance process can be trusted. This also has an impact on ROI and TCO. An OSS that is untrustworthy is likely to have lower ROI and higher TCO, as it will likely imply higher costs, which, in addition, may not be easily estimated beforehand.

This paper reports on a survey that has been carried out in the framework of QualiPSo [10], an EU-funded research project on the trustworthiness of OSS. Our results provide evidence that may be somewhat contrary to conventional wisdom. OSS stakeholders as a whole do not seem to attach a high degree of importance to ROI or TCO when deciding on the adoption of an OSS product. However, OSS stakeholders that have roles more directly related to economic results or who work in private companies may give economic factors more consideration than other OSS stakeholders. The interested reader should refer to [10] for more information on 1) the study whose part related to economic factors is summarized in this paper, 2) all of the investigations carried out about the trustworthiness of OSS products, and 3) the QualiPSo project in general.

The remainder of this paper is organized as follows. Section 2 describes the structure of the questionnaire that was used to elicit information rom the interviewees. Section 3 describes how the survey was carried out. Section 4 describes information about the sample (Section 4.1), the data analysis we carried out on the economic factors we investigated (Section 4.2), and additional information we obtained in our interviews (Section 4.3). Section 5 discusses some relevant threats to the validity of the study. Conclusions and an outline for future work are in Section 6.

2 The Questionnaire

With our questionnaire, we attempted to obtain answers on a number of factors that may be believed to affect OSS stakeholders' decisions when deciding whether to adopt an OSS product or component. The questionnaire was also developed keeping into account the actual literature on software product quality and OSS trustworthiness (e.g., [1, 5, 6]).

The questionnaire we developed is a general-purpose one: it can be used if OSS is used as is or is developed/modified; it is applicable to companies of any size; it targets any role (from the inexperienced developer to upper management levels); and it is not related to a specific application domain. In addition, we endeavor to understand how OSS is perceived by people from different types of ICT companies and with different roles.

The questions in the questionnaire can be mainly classified in three different categories:

1. *Organization, project, and role*. These questions are needed for profiling the interviewed person, the company he or she works for, the project(s) he or she participates in. Some of this information is obviously private and is collected for profiling reasons only. During the survey, it was made clear to the interviewees that this information would not be disclosed at all, and that, in the presentation of results, all information would be disclosed in aggregated form, so as to make it impossible to identify single respondents or single companies and their answers. Section 4.1 contains more detail on the profiling information we collected.

2. *Actual problems, actual trustworthiness evaluation processes, and factors*. These questions are needed to identify the main factors actually considered when evaluating whether to adopt an OSS product.

3. *Wishes*. These open-answer questions are needed to understand what should be available but is not, and what indicators should be provided for an OSS project to help its adoption. So, these questions addressed possible wishes that OSS stakeholders have on the information they would like to have about OSS products.

We grouped the factors in the following categories

- *Economic*. We asked about the importance of ROI and TCO, and any other indicators that may be important (these would be mentioned by the interviewees themselves in the "wishes" open questions).
- *Development*. For instance, we asked about the importance of the specific license, the availability of short-term support, the availability of documentation, etc., by means of closed- and open-answer questions. So, this category also included process factors that may influence OSS adoption decisions.
- *Product quality*. In this category, we included closed- and open-answer questions about the importance of external and internal qualities [9] of OSS. For instance, we asked about the importance of functionality, reliability, and maintainability as for external qualities, and the importance of modularity, structural complexity, and size, as for internal software qualities.
- *Customer*. The questions in this categories investigated the importance of customer-related issues, such as customer satisfaction and the existence of standards the software used by the customers needed to abide to.

In several questions, we asked the interviewees to provide an indication of the importance they give to each factor when they adopt OSS products. This importance was measured on a 0 to 10 scale, with value 0 meaning "not important at all" and value 10 meaning "of fundamental importance." The idea was not to actually attach absolutely precise meanings to these numbers, but to provide interviewees with a way to give us their idea of the relative importance ordering among these factors.

We began with a list of 35 factors. However, two more factors were included in our analysis as a result of the open questions, in which the interviewees could mention additional factors that they deemed important which we had not included in our initial list of factors.

3   The Empirical Study

We carried out a total of 151 interviews with respondents from Italy, Germany, France, Spain, Poland, Brazil, China, United Kingdom, and USA. The vast majority of the interviews were carried out in person and a few by phone. We believe this is the most effective way to elicit information and establish an effective communication channel with the interviewees. We wanted to collect information that was structured by means of closed-answer questions and additional information with open-answer questions and by talking with the interviewee.

We also carried out interviews by email, giving feedback and advice in an asynchronous way. The results seem to be fairly aligned and coherent with the direct interviews, but of poorer quality. For instance, we obtained far fewer details on open-answer questions. When the differences between the questionnaire obtained in a synchronous way and the questionnaires obtained in an asynchronous way become clear, we decided to continue with interviews only in person or by telephone.

All the interviews we carried out were individual ones, usually with one interviewee at a time, since we believed that it is important that the interviewees provide their own viewpoint without any sort of conscious or even unconscious interference due to the presence of other people, especially if belonging to the same organization.

4   Results

We first provide information about the sample of respondents (Section 4.1), which can be used to better interpret the statistical analysis results we discuss in Section 4.2. We also provide some additional information on economic issues that we collected from open-answer questions in Section 4.3. Even though it has not been subject to quantitative analysis, this information may provide useful knowledge about the eoconomic factors used when adopting OSS.

4.1   The Sample

We now provide information about a few relevant characteristics of the sample of interviewees. Table 1 contains the percentages of the roles for four organizational roles. Note that roles may not necessarily be mutually exclusive.

Table 1 Organizational Roles of Respondents

Role	%Yes	%No
Upper Management	30.8%	69.2%
Project Manager	20.5%	79.5%
Developer	39.7%	60.3%
OSS Expert	6.4%	93.6%

Table 2 reports on the education of the respondents. Note that the education degrees are not mutually exclusive. For instance, all PhD respondents also possessed some other education degree. Also, different educational systems exist in our respondents' countries, so we grouped them in common categories. For instance, "College 2-3 years" approximately groups the respondents that achieved a degree similar to an undergraduate degree. "College 4-5 years" groups those respondents that achieved a degree that required 4 or 5 years without any intermediate degree.

Table 2 Education of Respondents

Degree	%Yes	%No
High School	94.9%	5.1%
College 2-3 years	67.9%	32.1%
College 4-5 years	51.3%	48.7%
Master	38.5%	41.5%
PhD	11.5%	88.5%

Table 3 contains the percentages about the role of OSS in the respondents' organizations. Note that the education degrees are not mutually exclusive.

Table 3 Role of OSS in Respondents' Organizations

Role	%Yes	%No
Support software development	69.2%	30.8%
Part of other products	64.1%	35.9%
Customized or configured	79.5%	20.5%
Support for internal processes	65.4%	34.6%
Provide services to the outside world	66.7%	33.3%
Development platform	73.4%	26.6%
Target usage platform	76.1%	23.9%

Finally, Table 4 reports on the types of the organizations our respondents belonged to.

Table 4 Type of Organization

Type	Public	Private	No profit
Percentage	10.4%	80.5%	9.1%

4.2 Data Analysis

The data analysis we carried out allowed us to establish statistical significant ranking relationships between the 37 factors. We could safely carry out such an analysis because the values provided by the respondents are on an ordinal scale. We used the Sign Test, the Mann-Whitney Test, and the Wilcoxon Test [7] to assess the statistical significance of the relative rankings. As is usual in Empirical Software Engineering, we used a 0.05 statistical significance threshold.

The statistical analysis has actually allowed us to partition the factors in 8 separate groups, with the most important factors in group 8 and the least important ones in group 1. Our statistical analysis has also provided evidence for the existence of an ordering between factors belonging to different groups. For instance, customer-related factor "customer satisfaction" turned out to belong to group 7 and therefore it was believed to be more important than product-related factor "modularity," which belongs to group 6. No ordering can be established among the factors belonging to the same group. For instance, we do not have statistically significant supporting evidence to say that product-related factor reliability is more important than product-related factor maintainability or *vice versa*, since both are in group 7.

We also computed the means of the values provided by the respondents, because this is an expressive piece of information, as the 11-valued scale we used may be considered a Likert scale. At any rate, we found an almost perfect concordance between the ranking group of a factor and the mean value we obtained. By considering all of the 666 pairs of factors, the ordering between two factors according to their group differ from the ordering between them according to the mean value of respondents only for 12 pairs.

Not unexpectedly, the fact that an OSS product or component satisfies the functional requirements needed by the OSS stakeholder and its reliability appeared to be the most important factors. Somewhat surprisingly, structural size came in last, as the least important factor. This is somewhat surprising if one considers that a number of Empirical Software Engineering prediction models are primarily based on size (e.g., COCOMO [2]).

In general, both ROI and TCO were expected to be considered very important, but the results do not support this intuition. Table 5 contains the results we obtained on ROI and TCO, where

- "mean" is the arithmetic mean of the values provided by the interviewees
- "more" is the number of factors that turned out to be more important than the factor
- "equal" is the number of factors that turned out to be neither more nor less important than the factor
- "less" is the number of factors that turned out to be less important than the factor.

These unexpected results could be partly explained by the type of organization, education, and organizational role of the interviewees, as shown in Table 6, where

- "condition" shows the value of some profiling information on interviewees

Table 5 Ranking of ROI and TCO

Factor	Group	Mean	More	Equal	Less
ROI	3	5.722	22	6	8
TCO	2	5.633	29	5	2

- "mean if true" shows the value of the arithmetic mean obtained only with those interviewees whose profiling information is reported in column "condition"
- "mean if false" shows the value of the arithmetic mean obtained only with those interviewees whose profiling information is different from that reported in column "condition."

For instance, the average value provided by respondents in 'No profit' organizations as to the importance of ROI as a factor for adopting OSS is 3.167, while the mean value provided by all other respondents is 6.629. Specifically, the table only reports on those factors in which the impact of the truth value of a condition on the mean obtained is statistically significant at the 0.05 statistical significance level. For instance, the mean value provided by respondents in 'No profit' organizations as to the importance of ROI as a factor for adopting OSS is statistically significantly different from the mean value provided by all other respondents. We did not report on non statistically significant differences between means.

Table 6 Impact of Organization, Education, and Organizational Role on Means

Condition	Factor	Mean if true	Mean if false
type of organization: No profit	ROI	3.167	6.629
type of organization: Private	ROI	6.891	3.923
education: master	ROI	5.167	7.000
education: phd	ROI	3.750	6.705
education: phd	TCO	3.667	6.415
org role support: internal processes	TCO	5.531	7.160
org role support: sw development	TCO	5.558	7.318

4.3 Information from Open-Answer Questions

Other economic related factors and issues have been mentioned as important by at least some of the respondents as a part of the open questions. Here, we report a summary of the issues collected.

- *Ethics*. OSS experts and OSS supporters support ethic values instead of direct economical profits.
  - *Social cost*. Social cost may be considered as important as direct cost; this factor can be related to the more general ethics factor.

- *Development time*. Delivery time may be held as more important than the total cost of the product.
- *No use*. A very small number of the interviewees' organizations do not use OSS products a priori.
- *Closed specifications*. In some organizations, software systems are developed to fulfill closed specifications, which cannot be freely distributed. Hence, the implementation of closed specifications in a software product to be distributed sometimes negates the possibility to use OSS products.
- *Integration cost and effort*. Some products need to be integrated with existing software. Integration cost and effort have been reported to be high if there is the need to integrate proprietary software with OSS.
- *Risk analysis*. Risk analysis may be very important when evaluating the acquisition and use of a software system.
- *OSS market*. The possibility of becoming the driving force behind some OSS market niche by developing OSS is considered as the one of the driving economic factor.
- *Differentiate from competitors*. OSS software can be a distinguishing factor when compared to competitive products. This factor is going to lose some of its strength once OSS software is more widely adopted.
- *Full control of code*. This is considered an important economic factor, since unwanted economic dependencies can be avoided.

  - *Ability to contribute to evolve and adapt the software*. This factor can be considered a sub factor of full control of code.
  - *Independence from specific vendors and commercial products*. Independence and no vendor lock-ins are very important economic dependencies to be avoided. This factor can be considered a sub factor of full control of code.

- *ROI*

  - *Absence of license fees*. This factor stresses the fact that software licenses will be acquired for free, hence increasing the ROI.
  - *Try many solutions without spending money.*

- *TCO*

  - *Preference to stay with the same OSS product because expertise was acquired, and this reduces the effort*. This factor can be seen as a characteristic of TCO.

- *Acquisition*

  - *Ease of acquisition*. Ease of acquisition, especially for support and assistance services of OSS products, is considered important.
  - *Rules for spending money*. In many organizations, spending money to buy software can be a lengthy and complicate process. Since there is usually no money to be spent at the moment of OSS acquisition, OSS is regarded as a faster and easier way to acquire the needed software.

5   Threats to Validity

A number of threats may exist to the validity of a study like ours. We now examine some of the most relevant ones.

5.1   Internal Validity

Consistent with the literature, we used a 0.05 statistical significance threshold for the rankings and the impact of interviewees' characteristics of Section 4. We used non parametric statistical tests like the Sign Test, the Mann-Whitney Test, and the Wilcoxon Test [7], which are appropriate for ordinal variables like ours. We also dealt with the impact of interviewees' characteristics by taking the means of the values provided by the interviewees. This may yield results that are not always fully significant from a practical point of view, since comparing mean values of ordinal variables may not be significant from a strict Measurement Theory point of view [12, 8]. However, we believe that we have at least some evidence about the impact of those factors on the responses.

5.2   External Validity

The threats to the external validity of our study need to be identified and assessed. The most important issue is about the fact that our sample may not be fully "balanced," and that may have somewhat influenced the results. While this may be true, the following points need to be taken into account.

- It was not possible to interview several additional people that could have made our sample more "balanced," because they were not available or had no or little interest in answering our questionnaire.
- No reliable demographic information about the overall population of OSS stakeholders is available, so it would be impossible to know if a sample is "balanced" in any way.
- Like in many other empirical studies, we used a so-called "convenience sample," composed of respondents who agreed to answer our questions. We collected information about the respondents' experience, application field, etc., but we did not make any screening beforehand. Excluding respondents based on some criteria, which must have been perforce subjective, may have resulted in an "unbalanced" sample, which may have biased the results.
- We used the profiling information to find out which of the interviewees' characteristics may have an impact on the responses, as we showed in Section 4.
- We dealt with motivated interviewees, so this ensured a good level for the quality of responses.
- There is no researcher's bias in our survey, since we simply wanted to collect and analyze data from the field, and not provide evidence supporting or refuting some theory.

5.3 *Construct Validity*

An additional threat concerns the fact that the measures used to quantify the relevant factors may not be adequate. Our rankings are based on a 0 to 10 scale which allowed us to have sufficient variation to rank the factors and have indications on the impact of interviewees' characteristics on their responses. The very nature of our study required that we collect subjective data, as we wanted to capture OSS stakeholders' opinions, so no "objective" measure could be used to collect that information anyway.

6 Conclusions and Future Work

Our results, obtained in a survey that has been carried out in the framework of QualiPSo [10], an EU-funded research project on the trustworthiness of OSS, provide evidence somewhat contrary to conventional wisdom. OSS stakeholders as a whole do not seem to give a high degree of importance to ROI or TCO when deciding on the adoption of an OSS product. However, OSS stakeholders that have roles more directly related to economic results or who work in private companies give economic factors more consideration than other OSS stakeholders.

Future work will include carrying out additional interviews to widen the statistical sample we have and study if additional profiling factors of the respondents may be related to the adoption of OSS.

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