Utilization and Development Contribution of Open Source Software in Japanese IT Companies: An Exploratory Study of the Effect on Business Growth

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ABSTRACT
The usage of Open Source Software (OSS) has been more general these days and OSS are utilized in a wide range of business fields not only IT industries. Behind the expansion, there exist OSS development communities, where voluntary engineers dedicate their time and effort for the improvement. Considering development engineers in the companies as input resources, it is important to investigate the output of business growth. In this study, we conducted questionnaire survey to Japanese IT companies in 2013, and then analyzed the present state and relation between OSS utilization and development contribution. Our study revealed that Japanese IT companies are rather free riders of OSS, the volume of development contributions are far less than that of utilization. With regard to the effect on the business growth, the results of correlation analysis implicate that OSS utilization is related to the sales growth in the present term and that development contribution is related to the future growth of the employee number in the company. In order to explore the direct effect on the business growth, we constructed the models of multiple-logistic and logistic analyses, however, no direct and explicit determinants are found from the results of the analyses. Our research endeavors to investigate the OSS effect on the business growth are still on the way, but it is meaningful to provide the present state in numbers and hopefully this will lay some foundation for further study in this field.

Categories and Subject Descriptors
K.6.0 [**Management of Computing and Information Systems**]: General – *Economics*

General Terms
Management

Keywords
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1. INTRODUCTION
Open Source Software (OSS) is the software of which source code is open to public, and then the users can study and improve them for the users' needs and objectives. At present, we can observe that OSS is widely used in not only IT-related companies but also companies in a wide range of other business fields such as banking and manufacturing. The users and the companies utilizing OSS in business can benefit from using OSS at relatively lower cost (often free for simple use and introduction) compared to the proprietary software. However, we should not forget that there are tremendous effort and time dedicated by the software engineers all around the world participating in development communities.

In the early 2000s, when OSS started to draw attention, there were some doubts in the credibility of software, and then the vulnerability was viewed as a severe problem. However, we can now admit that the utilization of OSS is becoming more "general". Since there are strong requests of cost reduction from the demand side, cost-effectiveness of OSS cannot be ignored. At early times of OSS introduction, the OSS-related expertise and technology knowhow such as utilizing OSS in the internal system or proposing system integration services could be considered as competitive advantage. But the more OSS becomes general, the less competitive advantage can be retained. For IT companies, much deeper and wider knowledge as well as more strategic usage of OSS are strongly requested from the market.

In order to enhance the OSS development capability of the IT companies, contributing to OSS development is fundamental for rational IT companies. Otherwise, OSS development effort will soon be exhaustible by exploitation of digital copying as Ghosh (1998) explains in his "Cooking-pot market" model. From engineers' perspective, there are basically two means of development contribution: one is the engineers' voluntary effort and participation in the community, another is IT companies' organizational engagement in the community, which allow the belonging engineers to participate in the community while their working time. Development contributions have long been considered as engineers' individual activities, rather than organizational activities. However, it should be reconsidered differently from organizational viewpoints that OSS development contributions enable to retain the competitiveness in the market, at the same time utilizing them. As Chesbrough (2003, 2006, and 2008) describes "Open Innovation" in the context that innovation happens over the boundaries between companies, the companies should carefully take efforts to integrate internal and external resources together to gain extra values. The relation between IT

companies' internal engineer sources and the external OSS knowledge in the community are essentially the same as what "Open Innovation" indicates and applied to the IT companies.

From another viewpoint, we can consider that OSS engineers and internal software or system developed by OSS are "resources" of the company. When these resources are taken into businesses as input, we assume that these resources are "limited" as traditional economic theories refer. So, from business perspectives, it is necessary to consider its output (or outcome) as a result of exploitation of the limited resources. It can be said that the smart IT companies are utilizing OSS effectively in their business, while the belonging engineers are contributing the OSS development at the same time, either on work or off work (or both), given incentives to join in the OSS development community.

From researchers' perspective, it is important to investigate how OSS utilization and contribution relate each other and how OSS utilization and contribution (input resources) effect or affect the business growth (outcome). We conducted the questionnaire survey to the Japanese IT companies in 2012 and 2013 to examine the present state around OSS utilization and contribution in Japan. Based on the 2013 survey, this study overviews the OSS utilization and development contribution in the Japanese IT companies, and then further analyzes how OSS affects the business growth by OSS utilization and development contribution. This study attempts rather an exploratory approach to investigate the phenomena, however our study is the first time attempt to investigate the link between the OSS activities (utilization and contribution) and business growth in Japan. We are planning to do continued research in consecutive years 2012 - 2014, and hope that the series of studies can lay a foundation for further studies regarding the ripple effect of OSS in the actual business scenes.

2. Methodology

2.1 Research Question

The objective of this study is to examine the present state of OSS utilization and development contribution in the Japanese IT companies, and further investigate the effect on business growth. We draw our research questions as follows:

1) In what level or how much degree are the Japanese IT companies utilizing OSS and making contribution to OSS communities?

2) What is the relationship between OSS utilization and development contribution? Are they correlating together?

3) How OSS utilization and development contribution affect the business growth?

The final goal of our research is to find the OSS utilization- or development contribution-related determinant and influential factor(s) affecting the business growth of IT companies.

2.2 Questionnaire Survey

In order to obtain the data, we conducted detailed questionnaire survey to IT companies in Japan. The addressee lists were organized from the member lists of the organizations such as Open Source Consortium Japan, regional Information Industry Association in Chugoku area in Japan, Open Source Society Shimane, and Fukuoka Ruby and Software Industry Promotion Committee. The survey slips were sent to 650 companies in October 2013, and then 146 companies gave us replies (response rate 22.5%).

We employed the traditional postal mailing method, by which being able to send to the companies directly. Web-based survey would be easier to collect data from individuals, but it is difficult to identify the person representing the companies. In order to increase the response rate, the survey was conducted anonymously (no need to present respondents' name and company). All the questions are selective choices by Likert scale method, and then the collected data are considered as "categorical" and discrete data.

The research results of 2012 questionnaire survey were included in our study (2013). The results of 2013 survey were presented partially in our study (2014) but which limits the result of the correlation analysis between OSS utilization and development contribution. This is a full version of our research results of 2013 survey, exploring further to investigate the effect on business growth by attempting multiple-logistic and logistic analyses.

Table 1. Question Items

Company profile:
Q1. Home Prefecture
Q2. Year of Business Establishment (7 scale)
Q3. Main Business Field (7 categories + other)
Q4. Capital Stock (8 scale)
Q5. Number of Employee (9 scale)
Q6. Number of Developers - programmers, software engineers, etc. (9 scale)
Q7. Sales Amount (8 scale)
Q8. Growth Rate of Sales - present term (7 scale)
Q9. Prospect of Sales Growth Rate (7 scale)
Q10. Growth Rate of Employee Number - present term (7 scale)
Q11. Prospect of Employee Number's Growth Rate - subsequent term (7 scale)
Utilization of OSS - percentage of utilization (5 scale):
Q12. Utilization of Linux
Q13. Utilization of Apache HTTP Server
Q14. Utilization of Database technologies (MySQL, PostgreSQL, etc.)
Q15. Utilization of Programming Language Ruby
Q16. Utilization of Other Programming Languages (Perl, Python, PHP, etc.)
Q17. Utilization of Ruby on Rails
Contribution to OSS Communities - Human Resources and Direct Expenditures:
Yes/No, Amount of Human Resources (5 scale) and Direct Expenditures (4 scale)
Q18. Contribution to Linux
Q19. Contribution to Apache HTTP Server
Q20. Contribution to Database technologies (MySQL, PostgreSQL, etc.)
Q21. Contribution to Programming Language Ruby
Q22. Contribution to Other Programming Languages (Perl, Python, PHP, etc.)
Q23. Contribution to Ruby on Rails
Concrete outcome and effect - Degree of Agreement/Recpgnition (5 scale):
Q24. OSS utilization - 10 items
Q25. OSS contribution - 10 items

The number of questions is 25 in total as shown in Table 1. We adopted 6 OSS development projects for question category, such as Linux, Apache HTTP Server, Database (MySQL, PostgresSQL, etc.), Ruby, Other programming language (Perl, Python, PHP, etc.), and Ruby on Rails. Application-level software (such as ERP, CMS, CRM, etc.) was excluded in our study. Utilization of such application level software is becoming popular in Japan, however, case examples of development contribution of such software is rather limited in Japanese IT companies. So, we focused on the above 6 OSS. With regard to Ruby and Ruby on Rails, Ruby was developed by a Japanese engineer Mr. Yukihiro Matsumoto and a number of local municipalities in Japan such as Matsue and Fukuoka are promoting IT-related industries mentioning Ruby as "regional" resources. On the other hand, Ruby on Rails is the U.S. origin and being utilized and contributed more internationally as a web-based application framework. As Geer (2006) illustrates, Ruby started to receive a great deal of attention because of the

success of Ruby on Rails. However the origin and diffusion process of Ruby and Ruby on Rails are different, so we assumed there would be some differences and then asked separately.

With regard to how we measure the OSS utilization, we ask the utilization ratio of OSS - how much percentage of system is used or software development is utilized by OSS in total. “100%” in Linux means that the company uses Linux for all the server operating system, and then “50-74%” in Ruby indicates that Ruby is used in the range of 50-74% software development in the company for example. In this company, they probably utilize “Other Languages” for the rest of 25-50%.

As for the OSS development contribution, we asked contributions by human resources and contributions by direct expenditures separately. Contributions by human resources (HR) are the total amount of engineers’ labor cost of the past year, invested into OSS development activities in the business hour (converted by man/month). For example, if one engineer is involved in the OSS development activities in 20% of his business hour, assuming his labor cost is USD100,000 per year, the development contribution is counted to be USD20,000. On the other hand, contribution by direct expenditure (DE) is the total amount of monetary cost to support OSS development community such as donation, sponsorship fee or membership fee. The terms of currency in the questions were originally shown in Japanese Yen, however, the terms are converted into US Dollors (100JPY = 1USD) in order that the readers can capture the volume more easily.

With regard to the business growth indicators, we simply employed the growth rate of sales and growth rate of employee number in the present and subsequent term (prospect rate). As noted previously, all the questions are to be answered among selective choices, so the respondents just circle the growth rate such as “over 20% increase”, ”almost flat”, “10-20% decrease”, etc. There will be a discussion which indicators are suitable for reprenting the business growth. However we assume that the business growth can be concentrated into the sales and employee number in the long run, and then asked the growth ratio in two timeframe (present and subsequent term).

In 2012 survey, we asked concrete outcome and effect brought by OSS utilization and development contribution by free writing, and then collected qualitative information from respondents’ evaluation. In 2013 survey, 2 questions (Q24 and Q25) were prepared to collect the concrete outcome and effect based on the above qualitative infromation. The question asks how much degree or level, a respondent agrees or recognizes the outcome and effect of OSS. The details of question items are to be explained in Section 5.

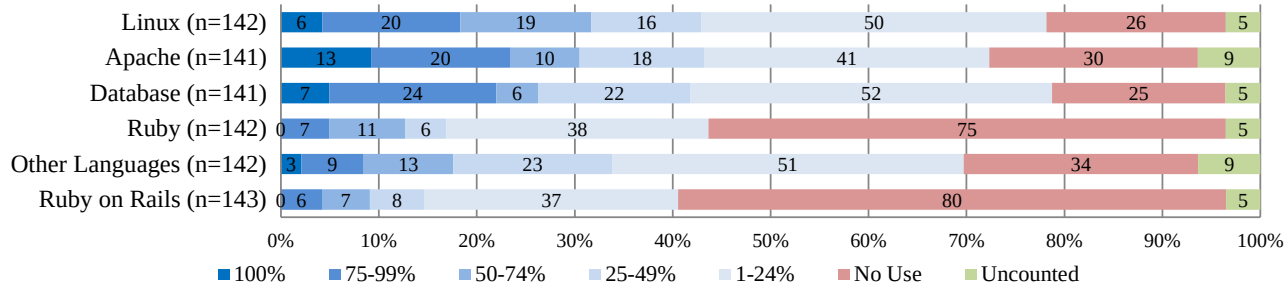

Figure 1. Utilization of OSS in Japanese IT Companies

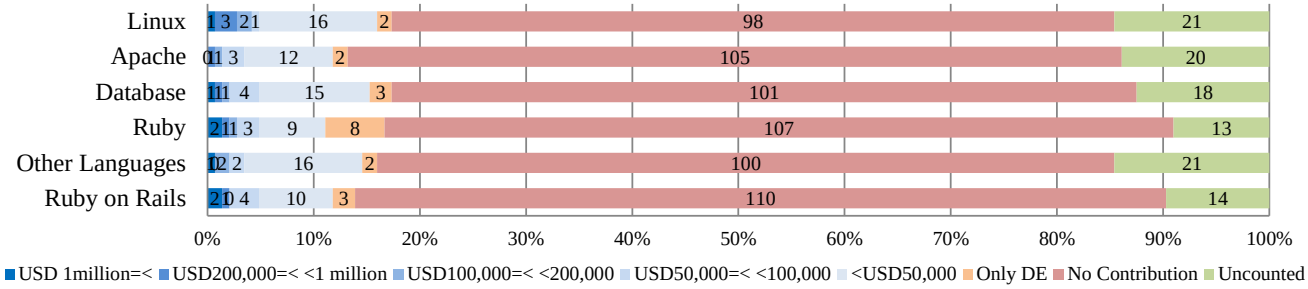

Figure 2. OSS Contribution to Communities by Human Resources in Japanese IT Companies (n=144)

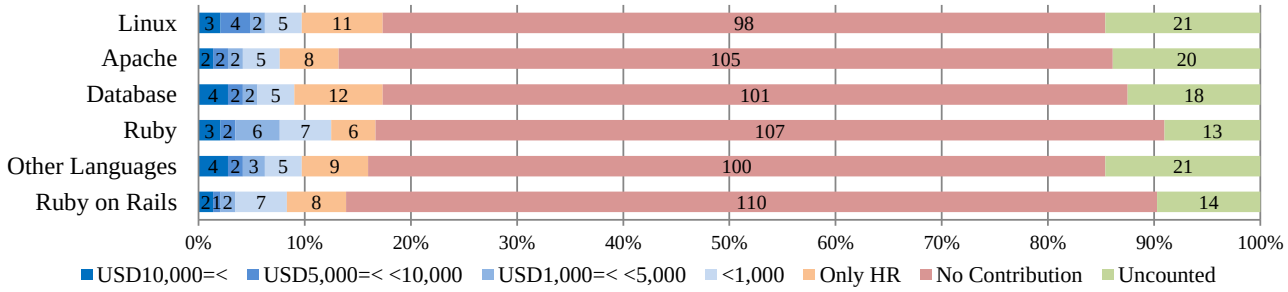

Figure 3. OSS Contribution to Communities by Direct Expenditures in Japanese IT Companies (n=144)

3. Results – Utilization and Contributions

3.1 OSS Utilization

As Figure 1 in the previous page indicates, Linux and Apache are utilized widely in the responded Japanese companies. Database and Other Languages are also utilized widely. It can be said that approximately 70% of companies are utilizing these OSS in some portion of their systems and development in Japanese IT companies. On the other hand, utilization of Ruby and Ruby on Rails are rather lower. But we can see that more than 40% of companies are utilizing these two to some extent.

3.2 OSS development Contribution

Figure 2 represents the OSS development contribution by human resources (HR) and Figure 3 by direct expenditures (DE). Compared to the degree of utilization, the percentage of companies contributing to OSS communities are very low in Japan. A certain percentage responded "uncounted", so this may include the companies which have not recognized in numbers. But even taken these into account, the dominant percentage of companies (approximately 70%) do not make contribution at all. The fact that most of Japanese IT companies use OSS without contributing to OSS development process might show that they are positioned as "free riders". Rather smaller percentage, but the survey also revealed that about 10 -15 % of IT companies do contribute to OSS development somehow in Japan.

3.3 Correlation between OSS Utilization and Development Contribution

In this section, we explore the correlation between OSS utilization and development contributions. Table 2 shows the correlation of utilization among OSS, Table 3 Correlations of development contribution by HR among OSS, and Table 4 Correlation of development contribution by DE.

As Table 2 shows, all the coefficients are statistically significant in 1% level, which indicates that when one company utilizes an OSS, it is more likely to utilize other OSS. Notably, the correlation of Linux with regards to Apache and Database are strong. This result indicates that most IT companies provide business solutions by utilizing OSS technologies based on Linux OS and kernel – lowest level of software (Kroah-Hartman et.al., 2009), and that Linux provides the foundation of OSS ecosystem in Japan. In addition, the correlation between Ruby and Ruby on Rails is comparatively strong. Ruby on Rails is development framework of Ruby, so this is an understandable result.

Table 2. Correlation of Utilization among OSS

	Linux	Apache	Database	Ruby	Other Languages	Ruby on Rails
Linux	–	.821 **	.780 **	.375 **	.662 **	.378 **
Apache		–	.757 **	.356 **	.628 **	.328 **
Database			–	.441 **	.653 **	.452 **
Ruby				–	.385 **	.885 **
Other Languages					–	.405 **
Ruby on Rails						–

Spearman's Rank correlation Coefficient ** 1% level of significance

As shown in Table 3, the correlations among contribution by HR are also strong. All the coefficients are significant in 1 % level. As the same context as OSS utilization indicated previously, the correlations of Linux regarding Apache and Database are strong. And also, it is observable that the correlation between Database and Other Languages are comparatively strong. This may indicate the fact that Other Languages such as Perl, Python, PHP are being developed (and contributed) in order to adopt effectively with Databases.

Table 3. Correlation of Contribution by HR among OSS

	Linux	Apache	Database	Ruby	Other Languages	Ruby on Rails
Linux	–	.793 **	.842 **	.550 **	.697 **	.561 **
Apache		–	.829 **	.518 **	.682 **	.593 **
Database			–	.479 **	.801 **	.517 **
Ruby				–	.583 **	.931 **
Other Languages					–	.621 **
Ruby on Rails						–

Spearman's Rank correlation Coefficient ** 1% level of significance

As shown in Table 4, the correlations among contribution by DE are also strong. All the coefficients are significant in 1 % level. With DE perspectives, it is interesting to find that the correlations are strong in the combinations between Linux regarding Database and Other Languages, Apache and Databases, Database and Other Languages, and Other Languages and Ruby on Rails.

Table 4. Correlation of Contribution by DE among OSS

	Linux	Apache	Database	Ruby	Other Languages	Ruby on Rails
Linux	–	.765 **	.901 **	.498 **	.874 **	.677 **
Apache		–	.909 **	.366 **	.746 **	.597 **
Database			–	.432 **	.865 **	.682 **
Ruby				–	.581 **	.784 **
Other Languages					–	.819 **
Ruby on Rails						–

Spearman's Rank correlation Coefficient ** 1% level of significance

3.4 Correlation between Development Utilization and Contribution of each OSS

In this section, the correlation between utilization and development contributions are analyzed. Table 5 shows the correlation between utilization and contribution by HR, and then Table 6 shows contribution by DE respectively.

Table 5. Correlation between Utilization & HR Contribution

HR / Utilization	Linux	Apache	Database	Ruby	Other Languages	Ruby on Rails
Linux	.161	.104	.025	.045	.099	.013
Apache	.047	.145	-.029	.053	.056	.038
Database	.131	.131	.094	.076	.117	.050
Ruby	.143	.092	.025	.357 **	.102	.312 **
Other Languages	.105	.138	.106	.214 *	.351 **	.196 *
Ruby on Rails	.228 *	.176	.106	.420 **	.189 *	.415 **

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

Table 6. Correlation between Utilization & DE Contribution

DE / Utilization	Linux	Apache	Database	Ruby	Other Languages	Ruby on Rails
Linux	.052	.009	-.013	.080	.032	.037
Apache	.072	.048	.012	.095	.013	.033
Database	.136	.086	.106	.083	.082	.043
Ruby	.098	.057	.044	.461 **	.164	.320 **
Other Languages	.139	.114	.144	.208 *	.217 *	.257 **
Ruby on Rails	.180 *	.141	.129	.400 **	.239 **	.343 **

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

As a whole in both HR and DE cases, correlations between utilization and contributions among Linux, Apache, and Database are not clearly shown. On contrast, the correlations among Ruby, Other Languages, and Ruby on Rails are shown distinctively. With these results, it can be concluded that most of IT companies in Japan make use of Linux, Apache, and Database technologies, and that these types of technologies are used in the same manner as "proprietary" software. As discussed previously, these OSS are being developed through the worldwide development communities. Hence, many of Japanese IT companies as "free riders" receive their accumulated economic values without paying much effort.

In contract, Ruby, Other Languages, and Ruby on Rails are "objectives" for development contributions. It can also be said that these technologies are still developing and have not yet gained stable valuation in business use in Japan. As a result, it is not easier to be a free rider at this point, so adopters are inherently positioning themselves as investors and contributors. It is very interesting to find the same trend in both HR and DE. With regard to the utilizations of Ruby, Other Languages and Ruby on Rails, the research results indicate that the companies utilizing these OSS technologies are contributing to the development by HR and also through DE. This trend is more explicitly shown by correlation analysis in the next section.

3.5 Correlation between Contributions by HR and DE

Table 7 below indicates the correlations between contributions by HR and DE. All the coefficients are significant in 1% level. We can find that there is a very strong trend that companies contributing by HR also contribute through DE, and that companies contributing by DE also contribute through HR, vice-versa. The companies appreciating OSS development effort by the communities contribute to the development by themselves, and then the companies supporting OSS through DE are likely to support other OSS and contribute to the community by HR. These results are quite understandable in one point, however it is even more interesting to illustrate this in numbers by the result of correlation analysis.

Table 7. Correlation between Contributions by HR and DE

HR \ DE	Linux	Apache	Database	Ruby	Other Languages	Ruby on Rails
Linux	.612 **	.418 **	.547 **	.380 **	.552 **	.461 **
Apache	.521 **	.615 **	.591 **	.319 **	.519 **	.461 **
Database	.594 **	.464 **	.569 **	.362 **	.629 **	.499 **
Ruby	.472 **	.344 **	.415 **	.550 **	.512 **	.558 **
Other Languages	.607 **	.465 **	.563 **	.368 **	.644 **	.563 **
Ruby on Rails	.492 **	.429 **	.479 **	.475 **	.566 **	.581 **

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

4. Correlation Analysis Results– OSS and Business Growth

In this section, we explored the effect on business growth by OSS utilization and development contributions by correlation analysis. The result regarding OSS utilization is shown in Table 8. Although significant levels differ from 1% to 5%, the correlations between all 6 OSS and growth rate of sales (present term) are shown. In the subsequent term, the significant correlation between Linux and Database are shown, however as a general trend, it can be suggested that the Japanese IT companies may recognize the effect (more likely "benefit") of OSS utilization on the sales growth at present term rather than the subsequent term. In contrast, no significant correlations (except for Database at present term) are shown with regard to the growth rate of employee number.

Table 8. Correlation between Business Growth and Utilization

	Growth Rate of Sales		Growth Rate of Employee Number	
	present term	subsequent term (prospect)	present term	subsequent term (prospect)
Linux	.302 **	.194 *	.159	.091
Apache	.189 *	.113	.129	.071
Database	.306 **	.219 *	.201 *	.134
Ruby	.207 *	.148	.149	.106
Other Languages	.237 **	.125	.164	.053
Ruby on Rails	.171 *	.098	.132	.044

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

Table 9 below indicates the result of the correlations between business growth and HR contributions. No significant correlations are shown in terms of growth rate of sales, but several significant correlations are shown for the prospect growth rate of employee number in the subsequent term.

Table 9. Correlation between Business Growth and HR Contributions

	Growth Rate of Sales		Growth Rate of Employee Number	
	present term	subsequent term (prospect)	present term	subsequent term (prospect)
Linux	.001	-.003	.108	.219 *
Apache	.023	.018	.054	.215 *
Database	-.029	-.018	.071	.182 *
Ruby	.000	-.053	.054	.115
Other Languages	.051	-.025	.127	.206 *
Ruby on Rails	.004	-.039	.046	.135

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

Table 10 below indicates the result of the correlation between business growth and DE contributions. The same as HR contributions, no significant correlations are shown in the growth rate of sales, but several significant correlations are shown for the prospect growth rate of employee number in the subsequent term. Particularly the correlation between database and subsequent term is strong at 1% significant level.

Table 10. Correlation between Business Growth and DE Contributions

	Growth Rate of Sales		Growth Rate of Employee Number	
	present term	subsequent term (prospect)	present term	subsequent term (prospect)
Linux	.032	.018	.052	.204 *
Apache	.118	-.010	.036	.191 *
Database	.019	-.001	.082	.248 **
Ruby	.035	-.040	.019	.151
Other Languages	.112	-.017	.062	.171
Ruby on Rails	.085	-.017	.080	.157

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

Taking these HR and DE results into considerations, it can be suggested that the Japanese IT companies may recognize the positive effects of OSS development contributions on employees. This is still an assumption drawn from the results, but the companies may recognize (or expect) positive impacts on the employees' human resource development by participating in OSS development communities through HR and DE. And this recognition (or expectation) is appeared in the prospect growth rate of employee number.

5. Correlation Analysis Results- Concrete Outcome and Effect related to OSS

The business growth indicators - growth rate of sales and growth rate of employee number are shown in numbers (percentages in category), so they are considered rather "tangibles". As we discussed previously, there are a number of direct and indirect outcomes and effects by OSS utilization and development contributions. Some of them are rather visible in numbers (such as cost reduction) or appearance (such as new business development), but many others are what is called "intangibles". Applicable to above both cases, these "intangible" outcomes and effects are difficult to capture in the comparable data. In 2013 survey, we attempt to capture the effect and outcome in categorical data by asking how much degree or level, a respondent agrees or recognizes the situation around the company. The question items for concrete outcome and effect are listed in Table 11. As mentioned previously, these sets of question items are summarized from 2012 survey. Some of the items such as "Company's technological strengh enhanced" are common, and others differ from OSS utilization to development contribution.

Table 11. Concrete Outcome and Effect of OSS

OSS Utilization	
1	Development cost reduced
2	Led to own business and new service development
3	Led to new customer development
4	Contracted OSS-related development project
5	Company's technological strength enhanced
6	Contracted upstream business (not subcontracting)
7	Found new business partner
8	Led to human resource development
9	become easier to rectuit new employee
10	Company's popularity and credibility improved
OSS Development Contribution	
1	Become easier to access new technology infromation
2	Become easier to access new business information
3	Led to own business and new service development
4	Led to specification drawing favorable to company
5	Company's technological strength enhanced
6	Found new business partner
7	Employees' motivation enhanced
8	Led to human resource development
9	Become easier to recruit new employee
10	Company's popularity and credibility improved

Table 12 below indicates the result of correlation analysis between the concrete outcome and effect of OSS and the business growth indicators. A number of significant correlations are shown in the growth rate of sales and employee number. It can be summarized that the recognition of the effect on the growth rate of sales is stronger than employee number, and that the recognition of the present term is stronger than the subsequent term. It is interesting to find that in all of 4 business growth indicators, "Led to human resource development" is significant in 1% level.

Table 12. Correlation between Concrete Outcome and Effect of OSS Utilization and Business Growth Indicators

	Growth Rate of Sales		Growth Rate of Employee Number	
	present term	subsequent term (prospect)	present term	subsequent term (prospect)
1 Development cost reduced	.226 **	.139	.168	.124
2 Led to own business and new service development	.269 **	.212 *	.229 **	.092
3 Led to new customer development	.285 **	.219 *	.252 **	.109
4 Contracted OSS-related development project	.268 **	.176 *	.231 **	.069
5 Company's technological strength enhanced	.253 **	.280 **	.150	.083
6 Contracted upstream business (not subcontracting)	.269 **	.267 **	.295 **	.124
7 Found new business partner	.250 **	.240 **	.277 **	.122
8 Led to human resource development	.330 **	.321 **	.347 **	.239 **
9 become easier to rectuit new employee	.270 **	.230 **	.279 **	.196 *
10 Company's popularity and credibility improved	.305 **	.192 *	.202 *	.114

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

The result of correlation analysis between concrete outcome and effect and OSS development contributions is shown in Table 13. It is notable that significant correlations are shown in all 10 items regarding the growth rate of sales in present term. On contrary, it is very interesting to observe that no significant correlations are shown in the prospect growth rate of sales in subsequent term. With regard to the growth rate of employee number, several correlations are shown in both present and subsequent term. In contrast to the growth rate of sales in the subsequent term, there are shown a number of significant correlations in the subsequent term (although significant level is lower 5%). This is still an assumption as previously discussed and we need to conduct more detailed survey or interviews to explicitly state this, however there is a possibility that the companies' recognition (or expectations) of OSS positive effects on human resources by development contributions are appeared in the prospect growth rate of employee number.

Table 13. Correlation between Concrete Outcome and Effect of OSS Contribution and Business Growth Indicators

	Growth Rate of Sales		Growth Rate of Employee Number	
	present term	subsequent term (prospect)	present term	subsequent term (prospect)
1 Become easier to access new technology infromation	.255 **	.180	.126	.183 *
2 Become easier to access new business information	.271 **	.178	.145	.150
3 Led to own business and new service development	.192 *	.152	.153	.119
4 Led to specification drawing favorable to company	.203 *	.144	.169	.098
5 Company's technological strength enhanced	.183 *	.121	.072	.176
6 Found new business partner	.269 **	.158	.272 **	.176
7 Employees' motivation enhanced	.252 **	.164	.209 *	.223 *
8 Led to human resource development	.276 **	.156	.219 *	.215 *
9 Become easier to recruit new employee	.282 **	.158	.270 **	.229 *
10 Company's popularity and credibility improved	.285 **	.142	.200 *	.182 *

Spearman's Rank correlation Coefficient ** 1% level of significance * 5% level of significance

6. Results – Logistic Analysis

In this section, we conducted logistic regression analysis to explore the effect on business growth influenced by OSS utilization and development contributions. Along with our exploratory approach, we tried to find the best possible "path" to explain the OSS effect on the business growth. Among a number of trial models, we reached to the models with a certain level of statistical significance.

In the process of our analysis, we faced the difficulty building significant models due to data technical problems (development contribution data are deviated strongly as shown in Figure 2 and Figure 3). So, we integrated the contribution data (both HR and DE) into dummy variables, yes (1) or no (0). There are 4 business growth indicators - growth rate of sales and growth rate of employee number in present and subsequent terms (originally 7 scales). Regarding these 4 indicators, we integrated into 3 scale data (-1, 0, 1) in multiple-logistic analysis in Model 1, and 2 scale data (0, 1) in logistic analysis in Model 2. Descriptions of the models are shown below.

Multiple-Logistic Analysis [Model 1]

Independent Variables:	Business Growth Indicators [4] - Decrease (-1) / Flat (0) / Increase (1) Reference Category: Almost Flat (0)
Dependent Variables:	OSS Utilization [6] OSS Contribution [6] - Yes (1) / No (0)
Control Variables:	Company Profile [3] - Scale of Capital - Scale of Developers - Years of Operation

Logistic Analysis [Model 2]

Independent Variables: Business Growth Indicators [4]
- Decrease, Flat (0) / Increase (1)

Dependent Variables: OSS Utilization [6]
OSS Contribution [6]
- Yes (1) / No (0)

Control Variables: Company Profile [3]
- Scale of Capital
- Scale of Developers
- Years of Operation

Table 14 and 15 represent the result of multiple-logistic analysis with business growth indicators as independent variables. The result of growth rate of sales is significant as a model with 5% level (observed from χ^2 statistics), however, the result for growth rate of employee number is not significant as a model.

Table 14. Result of Multiple-Logistic Analysis [Model 1] Growth Rate of Sales

Independent Variables Referece Category: Almost Flat		Growth Rate of Sales			
		Present term		Subsequent Term (Prospect)	
		Decrease Trend (-1)	Increase Trend (1)	Decrease Trend (-1)	Increase Trend (1)
OSS Utilization	Linux	.012	.790 +	.311	.403
	Apache	-.192	-.720 +	-.524	-.302
	Database	-.303	.537	.038	.274
	Ruby	-1.174	.064	-.361	.613
	Other Languages	-.027	-.497	.520	-.057
	Ruby on Rails	1.571	.086	.524	-.290
OSS Contributions	Linux	-1.656	-2.884 +	1.498	.965
	Apache	.218	2.187	.350	1.334
	Database	-2.103	-2.553	.547	-1.368
	Ruby	.903	.140	1.763	-.379
	Other Languages	4.135 +	3.067 +	-.096	-.721
	Ruby on Rails	-1.039	.851	-2.845	-.519
Company Profile	Scale of Capital	.070	-.699 *	.489	-.346
	Scale of Developers	.021	.286	.019	.598 **
	Years of Operation	-.429 +	-.439 +	-.675 +	-.647 **
Constant		1.442	2.535 *	-1.063	1.294
-2 Logl ikelihood (End)			174.17		154.84
$\chi 2$			50.19 *		44.83 *
Cox-Snell			.372		.340
Nagelkerke			.425		.401

** 1%Significant（both） *5%Significant（both） + 10%Significant（both）

Table 15. Result of Multiple-Logistic Analysis [Model 1] Growth Rate of Employee Number

Independent Variables Referece Category: Almost Flat		Growth Rate of Employee Number			
		Present term		Subsequent Term (Prospect)	
		Decrease Trend (-1)	Increase Trend (1)	Decrease Trend (-1)	Increase Trend (1)
OSS Utilization	Linux	-.264	-.385	1.703 +	.234
	Apache	.716	.270	-.447	-.249
	Database	-.556	.148	-1.754	.496
	Ruby	-.816	.116	-.735	-.071
	Other Languages	.010	.122	.053	-.298
	Ruby on Rails	.734	-.027	.404	-.390
OSS Contributions	Linux	.601	.948	-3.132	.324
	Apache	.744	-1.172	.870	-.709
	Database	1.645	1.047	2.463	.493
	Ruby	1.723	-.392	-.169	1.215
	Other Languages	-3.240	-1.114	-3.554	-.039
	Ruby on Rails	1.051	1.474	5.689 +	1.537
Company Profile	Scale of Capital	.425 +	.401	-.046	-.188
	Scale of Developers	-.278	.204	.052	.189
	Years of Operation	.016	-.297 +	-.274	-.072
Constant		-2.407	.810 *	-1.478	-.480
-2 Logl ikelihood (End)			172.94		152.53
$\chi 2$			31.45		30.77
Cox-Snell			.259		.252
Nagelkerke			.301		.306

** 1%Significant（both） *5%Significant（both） + 10%Significant（both）

From the result of the significant model (Table 14), there are a number of significant variables to be found such as utilization of Linux and contribution of Other Languages in the increase trend of the present term. However the contribution of Other Languages in the decrease trend of the present term is shown positive (if underlying logic is effective when the increasing trend is positive, decreasing trend should be negative). Likewise other significant variables, we have to admit there are difficulties interpreting the positive and negative signs from the model.

Next, Table 16 below displays the result of Model 2 logistic analysis. The results for the growth rate of employee number are significant (although 10% level), but the results for the growth rate of sales are insignificant (observed from the Wald Statistics). From the significant model with regard to the growth rate of employee number, Database utilization is found to be significant in 10% level. However, from these sets of models, we also have to admit that it is difficult to point out any explicit determinant indicator affecting on business growth.

Table 16. Result of Logistic Analysis [Model 2]

		Growth Rate of Sales		Growth Rate of Employee Number	
		Present	Subsequent (Prospect)	Present	Subsequent (Prospect)
OSS Utilization	Linux	.704 +	.318	-.366	.118
	Apache	-.612 +	-.215	.161	-.249
	Database	.610	.326	.224	.583 +
	Ruby	.196	.600	.258	-.027
	Other Languages	-.424	-.153 +	.103	-.252
	Ruby on Rails	-.179	-.372	-.124	-.388
OSS Contributions	Linux	-1.895	.293	.966	.645
	Apache	1.982	1.303	-1.306	-.647
	Database	-1.694	-1.235	.585	.241
	Ruby	-.120	-.669	-.904	1.184
	Other Languages	1.025	-.601	-.498	.231
	Ruby on Rails	.897	-.047	1.323	.590
Company Profile	Scale of Capital	-.263 **	-.515 *	-.391 *	-.062
	Scale of Developers	-.733	-.390 +	-.291	-.181
	Years of Operation	.327	.579 **	.354 +	.200
Constant		1.102	.791	.675	-.701
Wald Statistics		0.92	1.33	3.40 +	3.03 +
-2 Log likelihood		112.35	116.84	125.89	127.24
Cox-Snell R2		.286	.253	.143	.145
Nagelkerke R2		.383	.339	.193	.196

** 1%Significant（both） *5%Significant（both） + 10%Significant（both）

7. Concluding Summary

In this study, we investigated the present state of the OSS utilization and development contribution of the IT companies in Japan. Based on the questionnaire survey data, we conducted correlation and logistic regression analyses to explore the OSS effects on the business growth. As an exploratory research, we encountered some methodological challenges and limitations of interpretation of the results, however, there are a number of interesting research findings relating to OSS utilization and development contributions.

With regards to the research question 1), we found that many of Japanese IT companies are rather “free riders” in OSS utilization, without contributing to development in the OSS communities. Regarding the research question 2), it was suggested that Linux, Apache, and Database technologies are regarded as the manner of proprietary software in the Japanese IT companies, while Ruby, Other Languages and Ruby on Rails are still developing object for contribution. In addition, we found that there is a similar trend in OSS development contributions by HR and DE. With regard to the research question 3) the results of correlation analyses suggest that Japanese IT companies recognize the OSS utilization have

positive impacts on sales growth in the present term, rather than the subsequent term. Concerning the employee number, a number of significant correlations are shown in the prospect growth rate in the subsequent term, which suggests further research to examine the future positive impacts on human resources recognized by companies. In order to investigate more direct influential factor on business growth, we designed models for multiple-logistic and logistic analysis, however, the difficulty was encountered to interpret the results – coefficients of positive and negative signs. We consider that building more concrete model and data collection are necessary to meet with our future research challenges.

By the results of this study, we have not been able to reach the final goal of our research to find the determinant and influential factor(s) affecting the business growth. However, it can be interpreted that this result - no explicit determinant factor was found, shows the complexity of the issues itself. This also indicates the limitation of data collection through questionnaire survey and statistical analyses. In order to reach our final goal and disentangle the complexity, not only quantitative but also qualitative research approach should be considered. We now recognize that it is highly necessary to conduct a series of interview surveys to the IT companies' representatives and engineers in deeper level.

At last, we recognize the limitation of our research since scope and our data limits the Japanese IT companies. The present state and research findings are specific to the case of Japan. However, our research framework can be applicable to other countries and economies. We hope that some form of our exploratory research will lay the foundation of further researches to solve the complexity of the issue surrounding the OSS and business growth.

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