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오픈소스 소프트웨어 개발 플랫폼 활동이 IT 전문직 취업에 미치는 영향

Do Not Just Talk, Show Me in Action: Investigating the Effect of OSSD Activities on Job Change of IT Professional

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초 록

정보통신기술의 발달에 따라 IT 인력 채용 방식에도 많은 변화가 생겼다. 채용 담당자들은 이력서나 면접과 같은 전통적인 정보 이외에도 웹에서 구직자 정보를 검색할 수 있다. 오픈소스 소프트웨어 개발(OSSD) 플랫폼은 개발자들이 자연스럽게 IT 역량을 발휘할 수 있는 곳이자, 채용 담당자들이 적합한 후보를 찾을 수 있는 장소가 되었다. 이러한 맥락에서 본 연구는 취업 시 OSSD 플랫폼의 개발자 정보(구직 활동 여부, 개인정보 게시 정도, 학습 활동 정도, 지식공헌 활동 정도)가 취업에 미치는 영향을 분석하였다. 실증분석을 위해 웹 크롤러를 개발하여 대표적인 OSSD 플랫폼인 깃허브의 개발자 4,005명을 대상으로 데이터를 수집했다. 구직 기간이 짧다는 것은 취업의 성공적인 결과를 의미하기 때문에 구직 기간에 영향을 미치는 요인을 살펴보기 위해 생존분석법을 실시하였다. 본 연구의 결과에 따르면, 구직 현황을 명시적으로 게시한 개발자가 그렇지 않은 개발자보다 구직 기간이 짧은 것으로 나타났다. 개인정보 게시 정도, 학습 활동 및 지식공헌 활동 정도 또한 구직기간 단축과 긍정적으로 관련이 있는 것으로 나타났다. 본 연구는 향후 채용 담당자의 성공적인 구인뿐만 아니라 개발자의 효과적인 구직을 위한 OSSD 플랫폼의 전략적인 활용 방안에 시사점을 제시해줄 것이다.

ABSTRACT

With the advancement of information and communications technology, a means to recruit IT professional has fundamentally changed. Nowadays recruiters search for candidate information

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from the Web as well as traditional information sources such as résumés or interviews. Particularly, open-source software development (OSSD) platforms have become an opportunity for developers to demonstrate their IT capabilities, making it a way for recruiters to find the right candidates, whom they need. Therefore, this study aims to investigate the impact developers' profiles in an OSSD platform on their finding a job. This study examined four antecedents of developer information that can accelerate their job search: job- seeking status, personal-information posting, learning activities and knowledge contribution activities. For the empirical analysis, we developed a Web crawler and gathered a dataset on 4,005 developers from GitHub, which is a well-known OSSD platform. Proportional hazards regression was used for data analysis because shorter job-seeking period implies more successful result of job change. Our results indicate that developers, who explicitly posted their job-seeking status, had shorter job-seeking periods than those who did not. The other antecedents (i.e., personal-information posting, learning, and knowledge contribution activities) also contributed in reducing the job-seeking period. These findings imply values of OSSD platforms for recruiters to find proper candidates and for developers to successfully find a job.

키워드 : 오픈소스 소프트웨어 개발 플랫폼, 개방형 협업, 깃허브, 취업, 생존분석
Job Change, Open Source Software Development, Open Collaboration, Github, Proportional Hazards Regression

1. Introduction

Under fierce competition, it is crucial that firms hire appropriate employees and achieve the expected outcomes with limited resources and time [29, 33]. As information and communications technology (ICT) evolved, the ways to recruit employees have also changed [49]. As advancements in ICT have allowed anyone to generate and post their own content including their personal information on the Web, companies can access job seekers' transparent information [48]. Companies need to proactively choose the proper criteria in finding job seekers, who fit their requirements, by accessing -diverse information about job seekers on the Web rather than relying only on limited information from traditional methods such as résumés and interviews. In this vein, various online recruiting services match companies with job seekers by gathering Web data. For example, Google released a recruiting tool in 2017 called "Google for Hire," which automatically matches suitable job positions with job seekers' résumés based on social media information (e.g., Facebook, Instagram, and Twitter).

Although ICT helps find suitable positions for job seekers and proper candidates for recruiters, it is still difficult to find the appropriate candidates when the job positions require complicated skills and highly professional knowledge [3]. This difficulty is conspicuous in looking for IT professional. According to a Linux Foundation report in 2017, approximately 89% of companies experience diffi-

culties in finding developers with the proper skills and experience to meet the requirements of the companies. Furthermore, it is not easy to evaluate the skills needed to develop software programs during the interview [18].

In this context, open-source software development (OSSD) platforms have become a useful way for recruiters to find developers with required skills and for developers to show their ability. Open-source software (OSS) is defined as "software that is capable of modifying the source code, free to distribute, technically neutral, and is given with an autonomous license right" [47]. OSS is one of the representative examples of open collaboration and is an online environment for collective production through collaboration platforms [19]. OSSD platforms is important because the sustainability of the OSSD project depends largely on the active and voluntary participation of the OSSD platforms [15, 33, 37]. To accomplish successful job changes, software developers can contribute their codes without monetary rewards and accumulate information about their activities on the OSSD platforms to appeal to recruiters and reduce the uncertainties of limited information in a résumé [27]. Therefore, recruiters can gather developer information from OSSD platforms as one source of assessing candidates' capabilities. For example, Github.com, a popular OSSD platform, provides an individual profile page for each developer to present information about themselves such as affiliations, coding history, the number of followers and following, and the list of participating OSSD projects (i.e., repositories).

Despite the importance of OSSD platforms for both recruiters and job seekers, there is little empirical work examining an influence of developers' information in OSSD platforms on their finding a job. Most research on open knowledge communities such as OSSD projects has focused on the motivations of actors or their participation with respect to their sense of fulfillment, satisfaction, or economic incentives. According to Huang and Zhang [27], however, little research has focused on career benefits. More specifically, although many developers participate in OSSD projects to find new jobs or to achieve success in their career [20, 36, 39, 52], little is known about what activities developers can do and what information can make their profile more appealing to the recruiter [43]. Therefore, to determine how to attract recruiters' attention and consequently affect developers' job changes through OSSD platforms, we investigate how the detailed activities and information of developers affects their finding a job. Specifically, this study suggests the research questions as follows:

RQ1 : Does participating in OSSD platforms influence developers' job change?

RQ2 : If so, what activities in OSSD platforms are effective in finding a job?

As a first step in examining these research questions, we review the signaling theory [54], in the context of job market, explaining the human behavior of sending and seeking signals for reducing the information asymmetry. From the viewpoint of the signaling theory, we look at detailed activities of developers in OSSD platform, and we theorize and validate that these detailed activities in OSSD platforms have different effects on job change. For empirical analysis, we developed a Web crawler and gathered the individual Web page data of 4,005 developers on GitHub from January 2014 to December 2015 [30]. Since the shorter the job-seeking period, the more successful the job-seeking activity, we conducted proportional hazards regression for data analysis.

2. Literature Review

Previous research on OSSD usually investigated the motivations of free contributions of developers without material rewards [24, 25, 32, 60]. In addition, the types of licenses for each OSS also impact the rights of developers on OSS. Therefore, various researchers have attempted to verify the impacts of specified licenses on free contributions. Other streams of OSSD research are related to emerging leaders in large OSSD communities such as Linux [17, 21, 40, 45, 50, 63]. The communities for global software need to ensure the succession within their communities of the next leaders, who will manage the code contributions from various developers. Because they select leaders by voting, it is important to identify the antecedents of emerging leaders recognized by other developers. Currently, in the evolution of OSSD platforms such as GitHub or Sourceforge, many projects for OSS can be effectively conducted by one platform. Therefore, a new theoretical lens is needed to explain the roles of antecedents in the performance of OSSD or free contributions on these platforms. In addition, considering that free contributions are made by accepting code from other developers, researchers have focused on the factors that affect code acceptance [44]. Recently, developers have actively used well-visualized profile pages to appeal to their experience for recruiters or partners. On their profile pages, developers present individual Github addresses that contain the history of their activities in OSSD projects for self-promotion to their future coworkers or companies. Therefore, it is important that they show their abilities attractively. In this regard, drawing on signal theory, this study tries to verify the antecedents of job changes of developers in GitHub individual profiles using empirical data.

2.1 Signaling Theory in the Context of Job Market

Spence [54] introduced the signaling theory to explain the mechanisms of product/service purchases by reducing the information gap

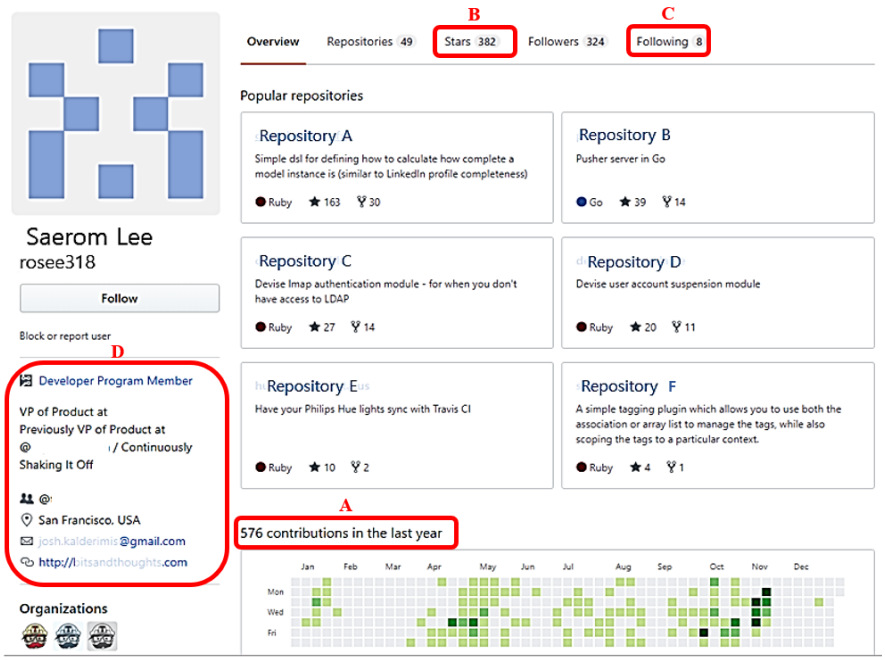
between sellers and customers. The signaling theory explains the rational behavior in sending and seeking signals to reduce the information asymmetry of two parties in various managerial and economic fields [11, 46]. This theory is used in understanding the recruiting process or job searching based on information asymmetry, which is critical for recruiters and job seekers [56]. It takes much effort and time to verify whether companies hired the appropriate employees among many candidates after hiring [27, 44]. Thus, companies invest time and effort in recruiting to avoid the risk of hiring unsuitable employees [54]. This situation can happen more frequently when it is hard for companies to evaluate the suitability of job applicants in a short time. Therefore, during the recruitment process, companies try to gather as much information about the job applicants such as working experience, education, and specialty as they can. Simultaneously, job seekers also try to provide their information to the recruiters in various ways such as résumés, job interviews, or recommendations from others. Companies can save costs and efforts by effectively matching their job requirements with the information of job seekers.

As social media becomes popular, recruiters can obtain information of job applicants outside traditional ones such as résumés, job interviews, or recommendation letters. Recruiters try reviewing applicants' information on social media to learn about their personalities, professions, and so on [7]. The software industry requires developers with complex and professional skills [3], so recruiters put more effort into finding appropriate candidates. Recruiters use activities in the OSSD platform as a way of verifying applicants' expertise [27]. Developers can demonstrate their skills in certain knowledge areas on OSSD platforms, so recruiters can determine the job suitability of developers based on the information in OSSD platforms. Marlow and Dabbish [43] directly asked how recruiters use GitHub as a platform for job recruiting and what information can be a useful signal to recruiters. They conducted seven semi-structured interviews with job seekers and employers to understand the hiring process from both sides and found that the employers use OSSD platforms to check the technical abilities and personal qualities of candidates for new hires.

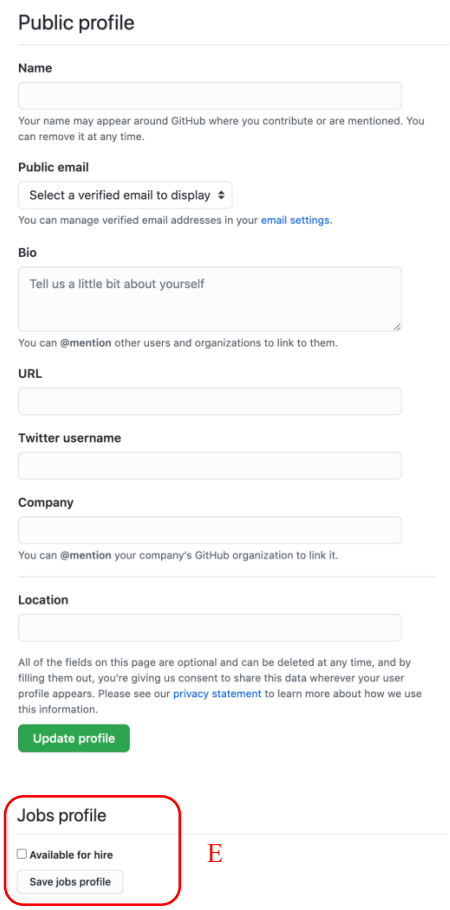
2.2 Developers' Activities in OSSD Platforms

Developers use OSSD platforms in many ways. To support effective collaboration, most of the OSSD platforms provide developers' individual profile pages. An example of a profile page in GitHub.com is shown in <Figure 1>. One way to participate in OSSD platforms is to develop OSS codes or give opinions on certain projects [62]. A higher number of contributions means the developer diligently par-

ticipates in the projects. They can get reputation by contributing complex and professional OSS codes. The profile page provides the number of yearly contributions, so anyone can easily know the developers' level of participation in the OSSD platforms (e.g., A in <Figure 1>). Another way of using OSSD platforms is to gain new knowledge through development information made by others. Developers can subscribe to projects that they are interested in. When a developer subscribes to a project, the timeline automatically informs him/her about all activities in the project, such as new or updated codes by others who joined the project. The profile page provides the number of subscribed projects (e.g., "Stars" as shown in B in <Figure 1>). Developers can also gain knowledge from certain developers by following them. When a developer follows other developers, the timeline automatically informs him/her about their activities, such as joining new projects or providing codes to existing projects. The profile page provides the number of following developers (e.g., "Followings" shown as C in <Figure 1>). Developers can also post personal information such as email address, website address, location, company name, a simple self-introduction, and hirable status in their profile pages (e.g., D in <Figure 1>). Developers can determine the degree of disclosure of personal information in their profile setting page (e.g., <Figure 2>) and explicitly express their job-seeking status (e.g., E in <Figure 2>).



〈Figure 1〉 Developer's Profile Page in GitHub.com



〈Figure 2〉 Profile Setting Page in GitHub.com

To understand the role of the developers' information in the recruiting process, this study categorizes developers' information on OSSD platforms into four groups: the signals to let recruiters know a developer is open to taking new jobs, learning, knowledge contribution, and personal-information posting. First, developers can turn on a sign to let recruiters know they are open to new jobs (e.g., "Available for hire" in <Figure 2>). A desire to find a new job is one type of explicit goal for participating in OSSD projects. This goal makes developers more actively participate than developers who only have intrinsic motivation. Turning on the "hirable" signal can immediately let others know they are looking for new job opportunities. Second, learning and knowledge contributions are important community activities that affect developers' hiring [27]. Learning is an intrinsic motivation of free contributions in OSSD projects [25, 52, 61]. The level of pursuing learning will affect job changes by assuming that developers who voluntarily study and build their skills will have better capabilities and more possibilities to advance their careers. Developers can gain new knowledge from development information in OSSD platforms. These sources of information can be certain developers or projects. Developers can set certain projects as favorites to subscribe to updates to these projects (e.g., "Stars" as shown in B in <Figure 1>) and set certain developers as favorites to subscribe to updates to these developers' activities (e.g., "Followings" shown as C in <Figure 1>). Third, knowledge contribution is related to the developers' reputation as generated by contributing complex and professional knowledge. Recruiters can use this information in gauging the experience or expertise of developers. Lastly, the amount of personal information is one factor that affects open collaboration [38] in terms of reliability. Developers can be more reliable if they post more specific

information about themselves [26]. Additionally, according to the signaling theory, reducing information asymmetry between job seekers and recruiters makes the recruiting more successful [27, 43]. Therefore, job seekers can provide information to recruiters by posting as much information as they can.

3. Hypotheses Development

Various rewards for free contribution on OSSD projects lead to different amounts and a diverse quality of knowledge contributions for developers. Developers who want explicit rewards (e.g., changing careers or taking license of software) for free contributions will spend their time and effort participating in OSSD projects. Roberts et al. [51] noted that developers who want to change their job status have a stronger motivation for free contribution in OSSD projects . In addition, Hann et al. [23] identified that developers with career concerns more actively participate or display their programming abilities than developers who participate in OSSD for enjoyment or satisfaction . In this regard, developers who desire for a job change tend to provide more information about their expertise and experience intentionally and voluntarily as a signal to recruiters. Thus, they would more actively participate in OSSD projects than other developers. Therefore, developers who explicitly present availability of taking new jobs (e.g., turning on the “Available for hire” sign as shown in <Figure 2>) will participate in OSSD projects more actively than others in terms of learning, knowledge contribution, and posting personal information. As such, we hypothesize the following:

Hypothesis 1a. *Developers who explicitly present job-seeking status will have more learning activities than others.*

Hypothesis 1b. *Developers who explicitly present job-seeking status will have more knowledge contribution activities than others.*

Hypothesis 1c. *Developers who explicitly present job-seeking status will post more personal information than others.*

According to Bradley et al. [9], training and skills development open more opportunities to gain advanced skills, resulting in job enrichment. Since open collaboration solves the problem of autonomous users, developers in OSSD projects can gain knowledge during the development process in OSSD platforms. Because learning from OSSD projects is an opportunity to increase the abilities of developers, Di Maggio and Van Alstyne [16] showed the positive relationship between learning and advancing careers. However, the findings related to the impacts of learning on job changes are inconclusive. Huang and Zhang [27], who verified the impact of learning on the likelihood of job change, asserted that learning from open collaboration can improve job satisfac-

tion and job performance, which will reduce the willingness to change jobs and decrease the likelihood of job hopping. Therefore, to draw conclusive results on the effects of learning on job changes, this study uses a more objective measurement: the number of subscribed projects and the number of following developers. This information about other projects or developers can encourage collaboration and enhance chances for communication [2, 8]. Accordingly, developers can consistently receive new information by subscribing to projects or following developers [58]. Therefore, a higher number of subscribed projects or following developers implies the expansion of learning opportunities based on the information of other projects or developers. As the effect of learning on job change is contradictory to previous research, learning activity on OSSD projects would have a positive effect on job changing. Thus, to analyze the effects of learning from projects and developers, respectively, we hypothesize as follows:

Hypothesis 2a. *The higher number of subscribed projects, the greater likelihood of job change.*

Hypothesis 2b. *The higher number of following developers, the greater likelihood of job change.*

Studies on OSSD projects have interpreted the meaning of knowledge contributions in OSSD projects in various ways. For example, von Krogh et al. [61] suggested that a person with greater amount of knowledge contributions reflects competencies to solve more complex problems. Faraj et al. [17] indicated that the experience of knowledge contribution is one of the three major factors affecting the perception of leaders' abilities. Leaders can achieve recognition as technical experts when they actively participate in the projects. Other research indicated that developers who contribute to OSSD projects more than others will gain more credibility as reliable decision makers [5, 42]. Furthermore, previous research explained that knowledge contributions in the open communities present the developer as an expert [27]. More than expressing expertise, these activities reflect the developers' enthusiasm and convey a positive impression on recruiters. In this regard, Huang and Zhang [27] validated the relationship between participation in OSSD communities and career changes. They measured the participation in OSSD communities based on knowledge contribution from other developers and identified that developers have more chances of changing careers when they contribute knowledge to communities. Thus, recruiters who are looking for skilled developers would consider knowledge contributions as a signal for more skilled and more experienced developers. As such, we hypothesize the following:

Hypothesis 3. *The greater the knowledge contribution, the greater the likelihood of job change.*

Lastly, studies highlighted the importance of transparently revealing individual information in online profiles to build trust [10, 28, 53, 64]. In computer-mediated communication environments, rich information can enhance the reliability of information providers [57]. Information about online reviewers in e-commerce platforms, such as the reviewers' real names, is closely related to their perceived reliability [41]. Zide et al. [65] highlighted the importance of information on profiles to appeal to recruiters on LinkedIn, a business and employment-oriented social networking service. In the context of OSSD, an individual profile page delivers detailed information about each developer. A developer can intentionally choose the information he/she posts in public. For example, on the profile page of GitHub, a developer can select which personal information should be public or not. Thus, the amount of personal information posting on their online profile can enhance trustworthiness as a proper candidate. Therefore, the hypothesis is as follows:

Hypothesis 4. *The more personal information posted, the greater the likelihood of job change.*

4. Data

4.1 Data Collection

For data collection, we created a Web crawler developed in Python and gathered a daily dataset of 5,964 active projects from January 2014 to December 2015. The projects were created during the data collection period and had more than five stars (tagging) within one week after creation. For data cleaning, we conducted the following steps: First, according to the definition of cooperation, we removed the projects with only one contributor [4]. Next, we gathered the information about the individual developers who own each project. Furthermore, we did not consider developers who did not report their job status on their profile during the entire data period. Additionally, we did not consider developers who only had one day of records due to the inability to track the duration of job changes. Finally, we used a flow sampling method [6, 59], which considers the users who tagged creating OSSD projects during the observation period [6]. Thus, the final dataset is an unbalanced monthly panel dataset with 4,005 developers and 926,398 observations.

4.2 Variables

To verify our hypotheses, our dependent variable is $JobChange_{i,t}$, which can be measured by the company name, $Company_{i,t}$, in a developer i's individual Web page at time t. Following Huang and Zhang [27], we can capture job changing when the job information is changed in the developer's profile (i.e., $Company_{i,t}$ is newly created or changed). When the developer changes his/her job in a certain

〈Table 1〉 Descriptions of Variables

Variables	Definition
$JobChange_{i,t}$	Change in job information (i.e., company name) of the developer i during time $t-1$ to t (not change = 0, change = 1)
$Hirable_{i,t}$	Whether the developer i explicitly indicates in the profile section that he/she is seeking a new job at time t (not hirable = 0, hirable = 1)
$Following_{i,t}$	Number of following developers of developer i at time t
$Staring_{i,t}$	Number of projects which the developer i bookmarks at time t
$Contribution_{i,t}$	Number of issues, pull requests, and commits contributed by the developer i within one year at time t
$Exposure_{i,t}$	Number of posted information of the developer i in the profile at time t (0, 1, 2, 3, 4, 5)

time (i.e., the time between $t-1$ and t), we identify the change. Here, $Company_{i,t-1}$ and $Company_{i,t}$ are the same, and we set $JobChange_{i,t}$ as 0; otherwise, when the developer changes their job information (i.e., $Company_{i,t-1}$ and $Company_{i,t}$ are different), we set $JobChange_{i,t}$ as 1. We check all cases of job changes as handling singular value. For example, we exclude the cases when the job name is changed to a similar name or it seems it was changed to correct misspelling.

For our explanatory variables, we investigate the effects of the four factors (job-seeking status, learning, knowledge contributions, and personal information posting) on job changes as shown in <Table 1>. First, we use $Hirable_{i,t}$ to measure the job-seeking status of developer i to changing jobs at time t. On the profile page, the developer can turn on the "Available for hire" function as shown in E in Figure 2 (i.e., the value of $Hirable_{i,t}$ is 1) for those seeking for a new job. However, for developers who turn off the "Available for hire" function or do not explicitly show intent to change jobs, the value of $Hirable_{i,t}$ is 0. Next, to evaluate learning, we measure the number of following and staring activities. In terms of $Following_{i,t}$, we use the number of followings in developer i's Web page at time t. Since GitHub provides the individual developers' number of followers and followings, this research considers the number of followings as the indicator of intent to learn from other developers. In terms of $Staring_{i,t}$, we use the number of staring in the developer i's Web page at time t as the indicator of intent to learn from other projects. To evaluate knowledge contribution, we measure $Contribution_{i,t}$, which is the number of yearly contributions listed on individual developer i's profile page at time t. In Github, yearly contributions include the number of posts about new ideas or questions (i.e., issue), the number of newly suggested codes (i.e., pull request), and the number of total code changes (i.e., commit) in OSS by a developer. The number of commits has been used in various studies as an indicator of knowledge contributions [1, 13,

22]. Lastly, to measure the amount of posting of personal information, we consider $Exposure_{i,t}$, which is the number of personal-information data that developer i opens to the public in the profile section at time t [38]. For example, when developer i opens all information (i.e., email address, website address, location, company, and simple self-introduction) to the public in the profile, the value of $Exposure_{i,t}$ is 5. If the developer does not open any information, the value of $Exposure_{i,t}$ is 0.

4.3 Descriptive Statistics

Before a detailed investigation of the antecedents of job changes for OSS developers, the descriptive statistics is presented in <Table 2>. The average number of commits contributed by a developer within one year is approximately 457. The average number of following is approximately 29 and that of staring is 140. Developers publicize approximately 2.8 items of personal information on average. In addition, 25% of the developers explicitly presented their intent to change jobs. <Table 2> also presents the correlation between these variables. Since we consider learning activities from projects and developers respectively, we measure *Following* and *Staring*. The correlation between *Following* and *Staring* is high (correlation = 0.458, $p < 0.01$) compared to other variables. Therefore, we developed models separately to analyze the effect of each learning activity.

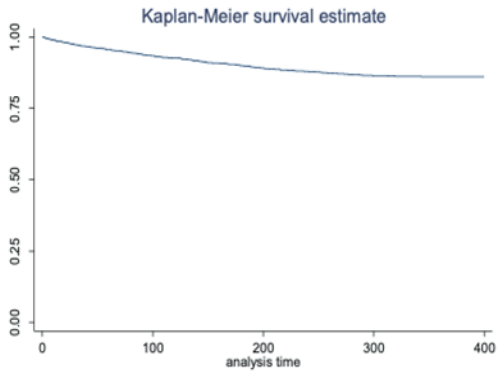
Since we assume that the shorter the job-seeking period, the more effective the job change, we calculate the job-seeking period of each developer. However, the job-seeking period is not easy to calculate because it is difficult to determine whether all developers who did not change their job during our observation period changed their job eventually after the observation period. Thus, we employ proportional hazards regression analysis in our research context. Proportional hazards regression analysis is also known as survival analysis, a type of regression model to determine the changes in the probability of survival over time [34]. The hazard ratio of a dependent variable indicates how the relative

〈Table 2〉 Descriptive Statistics and Correlation

	Mean	Std. Dev.	Min	Max	1	2	3	4	5
1. Hirable$_{i,t}$	0.250	0.433	0	1	1				
2. Following$_{i,t}$	29.337	80.464	0.007	2770.296	0.083***	1			
3. Staring$_{i,t}$	139.576	273.389	0	4084.641	0.154***	0.458***	1		
4. Contribution$_{i,t}$	456.551	1036.149	0.019	35022.27	0.070***	0.142***	0.209***	1	
5. Exposure$_{i,t}$	2.770	1.250	0	5	0.176***	0.152***	0.215***	0.134***	1

Note: The sample includes 926,398 observations of 4,005 users over the period of 2014 to 2015.
***p < 0.001; **p < 0.01; *p < 0.05.

likelihood of the event varies with variation in the independent variable. Here, the event is defined as a job change, so the survival in our model is the length of time or duration in which the developer does not change his/her job. To estimate the survival function of our dataset, we use the Kaplan-Meier (KM) estimator to estimate the survival function [31]. This considers the observed duration information only. Therefore, it is used for simple summary statistics in proportional hazards regression since it enables the user to estimate the distribution of the dependent variable without any assumptions. As shown in <Figure 3>, the probability of maintaining the status in seeking a new job (i.e., survival) at time *t* continuously decreases over time. The KM curve illustrates that approximately 15% of developers would find a new job within 350 days after developers started participating in OSSD projects. Therefore, activities in OSSD platforms have positive effect on developers' job change.



〈Figure 3〉 Kaplan-Meier Curve

5. Empirical Analysis

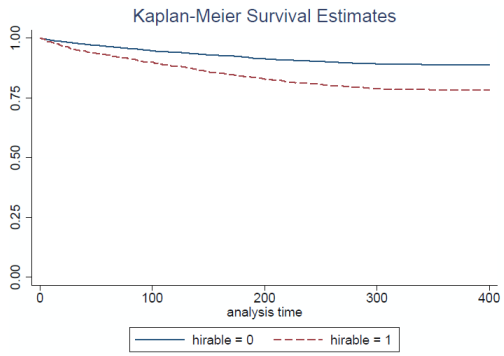
To test Hypothesis 1, we conducted a paired t-test to compare OSSD activities based on job-seeking status. As shown in <Table 3>, developers who show an intent to change jobs have a significantly higher number of followings, staring, commits, and personal-information posting than those developers who do not. In this regard, developers who explicitly present their intent to change jobs perform more actively in all aspects than other developers to appeal to recruiters based on their skill or attitude.

〈Table 3〉 Differences in OSSD Activities Based on Job-Seeking Status

	Group A *(Hirable = 0)*		Group B *(Hirable = 1)*		Mean Difference	t value
Attribute Levels	Mean	SE	Mean	SE		
Following	25.510	1.261	40.849	3.378	-15.329***	-5.235
Staring	115.261	4.125	212.644	11.777	-97.383***	-9.874
Contribution	414.652	16.149	582.457	43.879	-167.805***	-4.447
Exposure	2.643	0.024	3.151	0.031	-0.509***	-11.318
N	3,005		1,000			

Note: ***p < 0.001; **p < 0.01; *p < 0.05.

In addition, we draw the KM curves of two groups (the group that presents intention to find a new job [i.e., *Hirable* = 1] and the others [i.e., *Hirable* = 0]) to measure the overall effect of the explicit intent to change jobs on the survival rate. As shown in <Figure 4>, the comparison of KM curves shows that a developer who explicitly presents his/her intent to be hired (i.e., *Hirable* =1) has an inferior survival experience over time than the developer who does not (i.e., *Hirable* = 0). Specifically, the survival rate of the *Hirable* users (i.e., *Hirable* = 1) is much lower than that of the users who are not *Hirable* (i.e., *Hirable* = 0) over time. This result implies that developers who explicitly indicate their availability for new jobs are more likely to find new jobs than developers who do not.



〈Figure 4〉 Kaplan - Meier Curve

To test Hypotheses 2-4, Cox's proportional hazard model (PHM) is conducted [12]. Using this semiparametric statistic, we can derive a maximum likelihood estimator without considering a baseline hazard. We define the hazard ratio function of a developer i, $h_i(t)$ at time t as the probability of finding a new job during $(t+\Delta t)$ if he/she creates a project at time t. All developers have the same baseline hazard ratio function $h_0(t)$, and we estimate the proportion of each developer's hazard rate, which is different from each other depending on their characteristics. The hazard ratio function of PHM is the same as the product of the baseline hazard ratio and the exponential of the independent variables. $x_{i,t}$ represents the independent variables affect finding a new job. β is a coefficient of x representing the weight of the effect of each independent variable on the event.

The PHM result is presented in the first two columns in <Table 4>. Since the correlation between *Following* and *Staring* is high (correlation = 0.458, $p < 0.01$) compared to the other variables, we developed separate models to analyze the effect of each learning activity as shown in <Table 4>. Based on the estimates of the PHM analysis, developers who explicitly express intent to change jobs are more likely to change their jobs. In addition, a 1% increase in *Staring* is associated with a 12% increase in the probability of a job change, and a 1% increase in *Following* is associated with a 16% increase in the probability of a job change. Furthermore, we found that a 1% increase in *Contribution* is associated with approximately a 15% increase in the probability of a job change. Lastly, the developers who post more personal information

are more likely to change their jobs. Thus, Hypotheses 2-4 are supported ($p < 0.01$).

To check the robustness of our model, we conducted logistic regression, which shows the asymptotic equivalence with the PHM [14]. The last two columns in <Table 4> present the results of the logit model. The suggested factors have significantly positive effects on job changes, showing a strong agreement for all suggested factors with the PHM.

〈Table 4〉 Results of PHM and Logit Analysis

	PHM		Logit	
	(1)	(2)	(3)	(4)
Hirable	0.523*** (0.089)	0.513*** (0.089)	0.573*** (0.100)	0.560*** (0.099)
Staring	0.120*** (0.032)	-	0.127*** (0.035)	-
Following	-	0.166*** (0.036)	-	0.185*** (0.040)
Contribution	0.151*** (0.030)	0.155*** (0.029)	0.161*** (0.033)	0.165*** (0.031)
Exposure	0.231 (0.044)	0.222*** (0.044)	0.245*** (0.048)	0.233*** (0.047)
Cons	-	-	-4.111 (0.214)	-4.076 (0.205)
R^2	0.203	0.213	-	-
Pseudo R^2	-	-	0.060	0.063
N	4005	4005	4005	4005

Note: Standard errors between parentheses.
***p < 0.01; **p < 0.05; *p < 0.1.

6. Discussion

This study investigated the effects of developers' activities in OSSD platforms on job change using a dataset of 4,005 developers on Github. First, we examined the differences in developers' activities in OSSD platforms depending on availability for hire. The result of the t-test shows that developers who explicitly present availability for hire more actively participate in OSSD. In addition, the result of the Kaplan - Meier curve indicates that developers, who explicitly present availability for hire, have a shorter job-seeking duration. Furthermore, our findings showed contributions of activities in OSSD platforms on job change by conducting proportional hazards regression. As a result, we found a positive relationship between a job change and suggested antecedents (i.e., job-seeking status, staring, following, knowledge contribution, and personal-information posting).

This research has three theoretical contributions. First, this study contributes to research streams on the motivations of free contributions to OSSD projects by empirically investigating the relationship between participation in OSSD projects and explicit outcome (i.e., job change). While researchers investigate implicit and explicit motivations of OSS developers, little attention has been paid to the tangible outcomes of free contributions such as career success (job changes, salary growth, promotion, or job satisfaction). When developers desire a tangible outcome, it is difficult to anticipate the expected output in a short-term contribution. Therefore, it is important to verify how long it will take to obtain a tangible output. Specifically, this study focuses on

job changes among various tangible outcomes since there has been a lack of investigation on how the participation of developers on OSSD projects actually affects the job changes and job-seeking period as a tangible outcome. The results consistently showed that developers' OSSD activitiesaffects the job changes and job-seeking period. In addition, the suggested factors (i.e., job-seeking status, staring, following, knowledge contribution, and personal-information posting) have a positive impact on shortening job-seeking duration.

Second, this study provides a deeper understanding of the effects of developers' behaviors in open collaboration related to literature especially focusing on job change. Although previous research verified the antecedents of job change in open communities, most of them focused on only one or two representative OSSD projects. To overcome such limitation and to generalize the empirical results of previous research, this study the dataset of 4,005 developers in Github, one of the representative OSSD services. Github has 50 million developers and 100 million projects as of July 2020. Many recruiters actively look for developers in Github because it is known as a central hub for developers. Thus, it is worthwhile for both developers and recruiters to examine the exploratory variables for changing jobs via GitHub.

This research also has practical contributions. First, for developers, the empirical results of this research demonstrate that continuous and voluntary participation in OSSD platforms has a positive effect on extrinsic incentives (i.e., job change). Thus, software developers can strategically use activities on OSSD platforms by recognizing that their information (e.g., availability for hire) and coding activities on OSSD platforms can help present a good impression for recruiters. Specifically, this study offers job seekers guidelines on which information or activities on OSSD platforms create positive effects on job change and which one is the most effective. In addition, this study presents the need for software developers to participate in OSSD platforms and to utilize the activities on OSSD platforms as a portfolio since digitization has changed the recruiting process.

It is also helpful for recruiters to allow more information to be used in finding software developers, who fit their requirements, because software developers use the activities on OSSD platforms as a portfolio for job hunting. According to a report by Stack Overflow [55], only 17.3% of developers are actively searching for job opportunities, and the rest are passive about new job opportunities. Therefore, such developers tend to not actively use employment platforms (e.g., LinkedIn, CareerSite, and Monster), so it is effective for recruiters to find excellent potential candidates among developers in OSSD platforms (e.g., GitHub and Stack Overflow). Thus, this study offers recruiters guidelines on which information is an effective signal in finding proper candidates

when using public Web information such as coding histories in OSSD platforms in the initial stage of recruiting. In particular, the results of this research indicate that explicitly indicating the job status of the developers positively impacts job changes. Additionally, a signal that job seekers are actively participating in OSSD projects with free contributions and social relationships in OSSD platforms also shortens the duration of job changes. In this regard, platform providers can explicitly provide more detailed information about the developers' activities to other people, such as recruiters, to promote the free contributions of job seekers.

However, this study still has room for improvement. This study does not consider the project characteristics (e.g., difficulty or importance of each project). Therefore, future work can gather project-related data and verify the effects of OSSD projects to which the developers contribute and consider the important explanatory variables from the perspective of OSSD projects. In addition, considering the various developer abilities required by companies, it is obvious that not all abilities are considered to have the same value. In this regard, we need to provide different values for complex abilities and domain-specific knowledge for hiring. However, this study could not verify the different values of each ability. Therefore, future research can identify the value of each ability or add a different index for certain programming languages and experiences. Furthermore, knowing the actual intent to change jobs for developers, who did not share their job information, is impossible because our Web crawler can only access the information saved in the profile page of individual developers. We cannot also obtain nonbehavioral information about individual developers, such as demographic information (e.g., gender and educational accomplishment). To overcome these limitations, gathering primary data can be a solution. Future research can additionally consider other antecedents of job changes by conducting surveys or interviews of recruiters who have experience in hiring developers from OSSD platforms.

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