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The Impacts of Mobile Platform openness on The Knowledge Sharing intention of Third Party Developers

Goya Choi¹

Abstract

In mobile platforms, knowledge sharing behaviors of third party developers play a critical role in enhancing generativity of the platform, thereby leading to the success of the platform. Developers can generate new ideas and opportunities and enhance their expertise through knowledge sharing. This paper aims to explain the intention of knowledge sharing among third party developers with the Android case based on theory of reasoned action. The effect of platform openness, which consists of accessibility and controllability, is investigated as a critical motivation of knowledge sharing. Accessibility increases the size and diversity of developer pools and enables efficiency of communication among developers. Controllability enhances the needs of knowledge sharing due to the increase in uncertainty. The results show that platform openness enhances knowledge sharing intentions of developers. In addition, other motivational factors including self-efficacy, reciprocity, reputation, and rivalry are included in the research model, and the results show that self-efficacy and reciprocity stimulate knowledge sharing while a sense of rivalry hinders the knowledge sharing. This paper provides comprehensive framework to enhance understanding of knowledge sharing in the mobile platform context.

Keywords

Platform openness, Mobile platform, Knowledge sharing, Theory of reasoned action

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1. Introduction

Software platforms, which are defined as an extensible codebase of software-based system offering core functions to third party developers for application development, have changed the configuration of whole industries related to information and communication technologies (McIntyre and Srinivasan, 2017, Tiwana, 2013, Song et al., 2018). The locus of value creation has been shifted from giant hardware or software firms into the third party developers who directly provide value for end-users through the platform (Song et al., 2018). As the platform and third party developers are closely connected and interacted, they establish a mobile platform ecosystem (Tiwana, 2013). In the platform ecosystem, the role of third party developers becomes important because user's experiences of the platform mostly depend on applications (Tiwana, 2013).

Among diverse form of software platform, this paper investigates a mobile platform which serving building blocks for third party developers to produce their own apps. Even though platform owners provide limited technologies for third party developers, developers create and innovate novel applications with diverse functionality, contents, and design. For example, the number of available applications has been increased to 3.6 million of Android and 2 million of iOS in 2017. In the same year, mobile applications recorded 178.1 billion downloads deriving 81.7 billion dollars of revenues in worldwide (Statista, 2018). These unexpected outputs of third party developers beyond inputs of platform owners imply generativity of the platform (Wareham et al., 2014). Generativity determines platforms' competitiveness and leads to the growth and success of the platform (Wareham et al., 2014). The generativity can be enhanced through the knowledge sharing of third party developers. In the knowledge sharing process, third party developers can generate new ideas and expand business opportunities through interaction (Lin and Lee, 2006). At the same time, knowledge sharing facilitates use and integration of best practices, thereby creating a self-reinforcing cycle that enhances third party developers' capabilities (Zhou and Li, 2012). Therefore, knowledge sharing is a critical issue to understand generativity of the platform, and this paper is aim to provide framework for knowledge sharing among third party developers in the mobile platform context.

Knowledge sharing in the platform context is different from knowledge sharing within a single organization or virtual community. First, third party developers can not gain any direct rewards such as monetary benefits and promotion opportunities, which are main determinants of knowledge sharing in the organizational context. In the platform context, there is not a common goal every developer has to follow as well as no incentive systems operated by the platform owner in return for knowledge sharing. Thus, this paper considers motivational factors except for pure extrinsic rewards. Second, third party developers are potential rivals who use same resources from the platform owner and who compete in a same centralized market place. Since knowledge is source of competitiveness in application developments, a developer's knowledge sharing behaviors contain the risk of diminishing competitiveness of the developer. Because of the lack of extrinsic rewards and the risk of losing competitiveness, knowledge sharing behaviors of third party developers might have different motivational factors from those in the organizational or communities context. Thus comprehensive framework considering distinct motivations in the platform context is required.

In addition, this paper focuses on the platforms' characteristics because knowledge sharing behavior of third party developers can be different by which platform they mainly use. According to Stackoverflow, one of the largest community of software developers, the number of questions and answers related to Android is twice as many as those related to iOS.² It shows that knowledge about Android are more actively and frequently shared than iOS. Thus, platform characteristics derived by platform owner's strategic decisions can alter knowledge sharing behaviors of third party developers. Among diverse characteristics of platforms, this paper focuses on platform openness, which is major differences between Android and iOS. Platform openness is considered as an enabler of knowledge sharing behaviors of third party developers in this paper. Platform openness allows third party developers to use, develop and commercialize their application without

² In the survey of Stackoverflow, respondents of mobile developers consist of 64.8% of Android developers and 57.6% of iOS developers allowing multiple responses. It implies that the proportion of Android developers to iOS developers in Stackoverflow is similar. Thus, the questions and answering among Android developers are likely to more active than those of iOS developers considering the portion of the developers.

any restriction. There are two distinct approaches of platform openness, granting access and devolving control (Boudreau, 2010). Granting access approach focuses on the accessibility and transparency of the platform. Since accessibility lowers entry barriers of the platform, it increases the size and diversity of third party developer pools which is a source of knowledge sharing (Boudreau, 2010). In addition, transparency enhances understandings of third party developers by providing common standards, rules and guides of the platform (Benlian et al., 2015). Thus it enables third party developers to communicate and interact effectively in knowledge sharing process. Furthermore, the platform owner can relinquish their controls over the platform. Without a control of the platform owner, behaviors and outputs of third party developers are not monitored and regulated, and third party developers can freely generate their applications as they want (Tiwana, 2015). In this case, third party developers' motivation to share knowledge might increase in order to reduce risks of uncertainty and enhance their creativity through learning each other. Therefore, this research investigates effects of these two approaches of platform openness on knowledge sharing of third party developers.

Theory of reasoned action provides a theoretical framework in this paper. Theory of reasoned action assumes that an individuals' volitional behavior such as knowledge sharing is influenced by the behavioral intention which is determined by attitudes toward and subjective norms of the behavior. The research model presents several motivational factors including platform openness, self-efficacy, reciprocity, reputation, and rivalry, which influences on attitudes or subjective norms. Since every variable is related to individuals' perception or intention, I collected data through an online survey targeting third party developers and analyzed the data with structural equation modelling method.

This paper expands the context of knowledge sharing from a single organization to a platform ecosystem, and it provides several contributions. First, this paper investigates the platform openness as a significant determinant of knowledge sharing in the platform ecosystem. In the results, platform openness significantly induces positive attitudes and subjective norms of the developer. It implies that platform openness might lead to increase in generativity of the platform by vitalizing the knowledge sharing among third party developers. Second, platform openness is treated as a multidimensional construct, which

consists of accessibility and controllability. Previous studies have used a single construct to measure the platform openness. However, a platform owner can design and implement diverse open strategies in order to reach a certain degree of the openness. Thus platform openness should be measured with multiple constructs considering these different open strategies. The results describe that accessibility and controllability are discriminated from each other, and both constructs are instrumental in overall perception of platform openness. Third, in the context of platform ecosystem, competition among third party developers is an issue for knowledge sharing among them. A sense of rivalry to other developers significantly deter knowledge sharing of the developer. Finally, this paper reconfirms the significant effects of motivational factors from previous researches. Reciprocity and self-efficacy increase knowledge sharing in the platform context, which are crucial motivations of knowledge sharing in the organizational or community context. On the other hand, third party developers does not care about incentives of reputations from knowledge sharing while reputation is significant motivation of knowledge sharing in virtual community researches.

This paper consists of six sections as follows. In section 2, I review previous literatures related to the concepts of mobile platform openness as well as knowledge sharing intentions and motivations with theory of reasoned action. The research model is presented in section 3 with hypotheses. Methodologies and measurement items are introduced in section 4, and the research model is analyzed in section 5. Based on literatures and results, I propose conclusion and discussion in section 6.

2. Literature review

2.1. Mobile platform ecosystems and the platform openness

Software platforms have played a central role of development of information and communication technologies (ICT) (Tiwana, et al., 2010). Software platforms provide core functionalities to develop external modules and connect them with interoperability (Tiwana et al., 2010). Mobile operating systems, which are referred to mobile platform in this paper, are representative form of software platform, and it drives the transformation

for mobile industries into the smart era. Mobile platforms such as Android and iOS provide base of development and innovation of applications. The importance of mobile platform becomes increased as platform companies have expanded their platforms into various ICT industries such as Internet of Things, Smart cars, and diverse media contents.

Mobile platforms serve a group of building blocks for app development and a market place of apps, and it enables third party developers to produce and commercialize their own applications (Qiu et al., 2017). At the same time, third party developers flourish the platform with their applications which attract more users into the platform. These mutual interactions and continuous coevolution between a platform and third party developers create the complicated network between them, which refers to a platform-centered ecosystem (Adner and Kapoor, 2010). In a platform ecosystem, third party developers create a new outputs beyond intention and expectation of the platform owner based on the network among third party developers, which refers to generativity (Wareham et al., 2014). Zittrain (2006) initially presented the concept of generativity as the capacity of a technology to make unanticipated changes driven by broad, heterogeneous, and uncoordinated crowds. Hence, mobile platform's generativity can be defined as the platform's capacity to induce unexpected changes through close interactions among third party developer. Generativity encourages innovations not only of an individual application but also of the whole platform ecosystem.

Since a crowd of third party developers is a prerequisite of generativity, platform owners are attempt to involve a large number of developers in the platform ecosystem. In order to attract more third party developers, mobile platform owners can open their platform to them. Openness of mobile platform allows third party developers to use, develop and commercialize applications based on the platform technologies without restrictions (Boudreau, 2010, Eisenmann et al., 2008). There are two distinct approaches of platform openness, granting access and devolving control (Boudreau, 2010). Granting access approach focuses on the accessibility and transparency of the mobile platform. Since accessibility lowers entry barriers of the platform, it increases the diversity of third party developers. In addition, transparency enhances understanding of third party developers by providing common standards, rules and guides of the platform, thus it enables third

party developers to communicate and interact effectively. Furthermore, the platform owner can relinquish their controls over the platform. Without a control of the platform owner, behaviors and outputs of third party developers are not monitored and regulated. It allows third party developers to freely create their applications as they want. In this case, third party developers' interaction might be stimulated in order to reduce risks of uncertainty and enhance their innovativeness through learning each other. Therefore, this paper investigates effects of these two approaches of platform openness on interactions of third party developers. In particular, we focus on knowledge sharing between third party developers as a representative interaction behaviors among third party developers.

2.2. Knowledge sharing in platform ecosystem level

Knowledge is personalized information of an individual (Wang and Noe, 2010, Alavi and Leidner, 2001). Individuals acquire and process information through a reflection, enlightenment, and learning as well as generate their own know-how. Thus knowledge includes both information and know-how (Wang and Noe, 2010, Zander and Kogut, 1995, Alavi and Leidner, 2001). For example of the mobile platform, knowledge of third party developer includes information they gain from external sources such as source codes, manuals, and recent news as well as know-how or skills they create themselves based on previous experiences. Individuals share these knowledges in order to solve problems, enhance expertise, or apply policies and process (Wang and Noe, 2010). In the knowledge sharing process, third party developers can generate new ideas and expand business opportunities (Lin and Lee, 2006). In other words, knowledge sharing facilitates the innovation of third party developers, thereby flourishing the mobile platform. Therefore, platform owners are attempt to encourage knowledge sharing among third party developers in order to enhance competitiveness of the platform. In this paper, knowledge sharing is defined as a third party developer's behavior to provide his/her knowledge to others (Bock et al., 2005).

Since knowledge is personalized and embedded in individuals, a knowledge sharing behavior depends on individuals' volition to provide and to express their knowledge in a manner as to be understood by others (Bock et al., 2005, Alavi and Leidner, 2001). Generally, knowledge sharing is not a compulsory or enforced behavior but a voluntary

behavior which utterly depends on willingness of the individuals (Bock et al., 2005). Theory of reasoned action (TRA) delineates an individual's decisions of a volitional behavior and presents motivational factors influencing the behavior (Montano and Kasprzyk, 2015). According to TRA, a most significant predictor of volitional behavior is behavioral intention which is determined by attitude toward and subjective norm related to the behavior (Montano and Kasprzyk, 2015, Bock et al., 2005). These two main construct, attitude and subjective norm, are influenced by various motivational factors such as personality traits and environmental features (Montano and Kasprzyk, 2015). This paper adopts TRA as a theoretical background to explain a knowledge sharing intention of third party developers, and we suggest appropriate motivational factors in the mobile platform context.

Previous studies have mainly researched on a knowledge sharing motivation in team or organizational contexts. At the team level, Mehta et al. (2014) investigated knowledge sharing intention of software development teams, and Ghobadi and D'Ambra (2012) focused on a knowledge sharing intention of managers of a project team. At the organizational level, Lin (2007) and Bock et al. (2005) tested employees' motivational factors of knowledge sharing with colleagues in the company as well as Lin and Lee (2006) researched on senior executives' perception to encourage knowledge sharing in companies. Moreover, Lam and Lambermont-Ford (2010) also explored knowledge sharing motivation in bureaucracy organizations, and Fullwood and Rowley (2017) studied on knowledge sharing among academics. These studies focus on individual benefits including gaining extrinsic rewards such as increase in salary, promotion, and job security and strengthening relationship with colleagues who know each other and work together in the same organization. In addition, managerial supports and organizational climates are also considered as a critical factor of motivation of knowledge sharing. In the platform context, third party developers are not involved in identical organizations as well as not share common goals and interests. Moreover, developers do not receive any extrinsic rewards from the platform owner in return for knowledge sharing. Therefore, extrinsic rewards might not be considered to explain knowledge sharing in the platform context.

In previous literature, knowledge sharing in professional virtual communities also has been researched (Hsu et al., 2007, Chiu et al., 2006, Lee Endres et al., 2007, Chen and Hung, 2010, Wasko and Faraj, 2005, Feng and Ye, 2016, Xu and Li, 2015, Yang and Lai, 2011). Virtual communities do not have strict boundary and clear goal, and expert and practical knowledges are shared in the communities (Hsu et al., 2007). Researches on virtual communities emphasize self-efficacy and reciprocity relationships based on trust (Wasko and Faraj, 2005, Xu and Li, 2015). Additionally, perception of identification or belonging of individual is considered as a critical predictor of knowledge sharing (Chiu et al., 2006). Since most of knowledge sharing of third party developers can be conducted through online channel such virtual communities and blog, motivational factors of knowledge sharing in virtual communities might be significant in the context of mobile platform. However, there are two major differences between them. First, third party developers who use the same platform are likely to have common development experiences due to platforms' characteristics. They use the same program languages, development tools, application market, guide documentations, and development resources, which establish platform's distinct climates from other platforms, thus motivational factors which address the platform characteristics or climates is required. Second, third party developer are in more direct competitor position. As a valuable resource and a locus of competitive advantages, knowledge enables an developer to achieve superior performances (Lee Endres et al., 2007). Because knowledge of third party developers determines the competitiveness of their applications, knowledge sharing to other developers can undermine their competitiveness. Thus, perception of rivalry against other developers might influence the knowledge sharing intention.

3. Research model

Based on theory of reasoned action, we develop the research model as shown in Figure 1. The research model consists of three parts. First, we adopted constructs from theory of reasoned action to explain knowledge sharing behaviors. Theory of reasoned action assumes that knowledge sharing intention is a decisive predictor of knowledge sharing behaviors. Thus this paper focuses on a knowledge sharing intention of third party

developers and investigate which motivational factors influence on the knowledge sharing intention. Second, we use platform openness as a main motivational factor of knowledge sharing intention. Platform openness is considered as multidimensional constructs with accessibility and controllability. Platform openness might influence common practices, understandings and experiences of third party developer in the platform ecosystem, thereby driving the distinct knowledge sharing behaviors. Third, other motivation factors from previous studies are included in the research model. Several constructs such as self-efficacy, reciprocity, reputation and rivalry included in the research model.

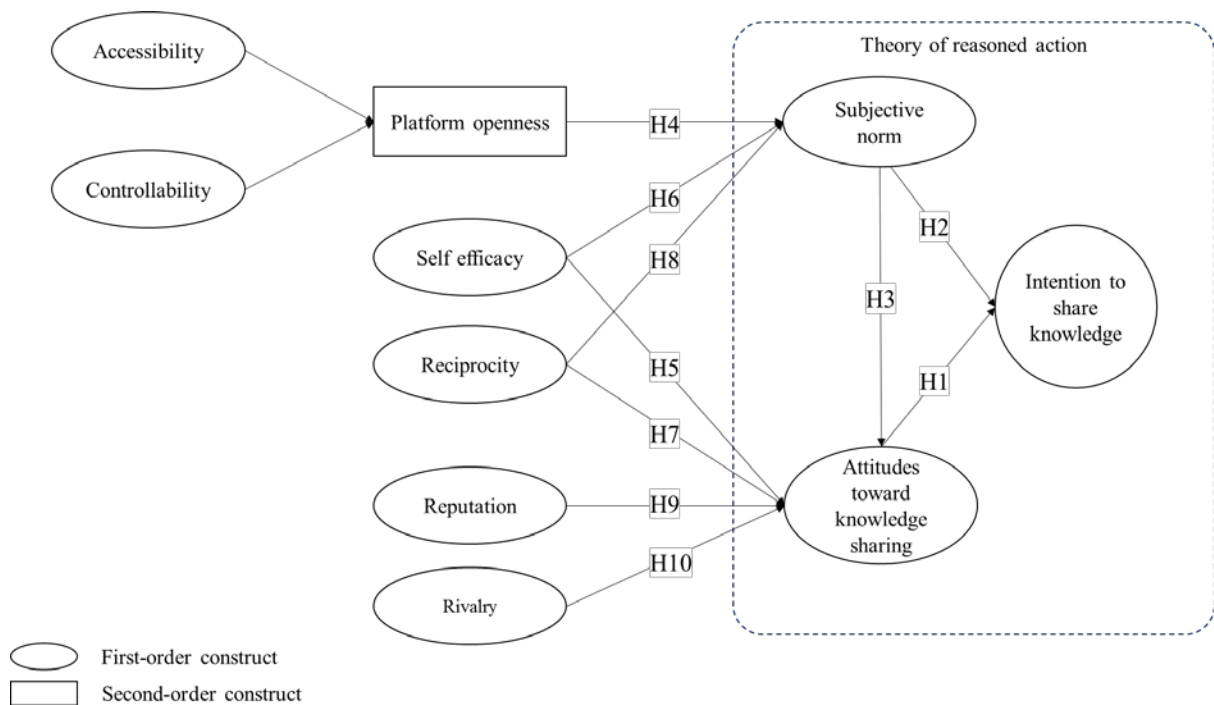


Figure 1. Research model

3.1. Theory reasoned action

Theory of reasoned action describes determinants of performing a volitional behavior of an individual (Montano and Kasprzyk, 2015). Knowledge sharing as a representative volitional behavior can be clarified by the theory (Bock et al., 2005). The likelihood of a knowledge sharing behavior depends on an individual's knowledge sharing intention, and the intention is determined by two critical predictors: attitudes and subjective norms

(Montano and Kasprzyk, 2015, Bock et al., 2005). First, attitude toward knowledge sharing is defined as the individual's beliefs about outcomes or feelings of performing knowledge sharing (Bock et al., 2005). If a person, who thinks that knowledge sharing behaviors leads to positive outcomes or favorable feelings, might be inclined to have intention to share knowledge (Montano and Kasprzyk, 2015). This leads to:

H1. Positive attitude toward knowledge sharing might increase the intention of knowledge sharing.

Second, normative norms refer to perceived social pressure from a referent group to perform or not perform a knowledge sharing behavior (Bock et al., 2005, Montano and Kasprzyk, 2015). An individual's behavioral intention can be influenced by whether others who are important to the individual think the individual should do the behavior or not (Montano and Kasprzyk, 2015). In other words, if the group where an individual is involved in have positive norm to knowledge sharing, the individual is likely to share knowledge in order to meet expectations of others in the group (Montano and Kasprzyk, 2015). Hence,

H2. Positive subjective norms to share knowledge might increase the intention of knowledge sharing.

Two predictors of knowledge sharing, attitude and subjective norm, have strong correlations (Bock et al., 2005). Individual beliefs or feelings might be determined by the subjective norm through social influence processes (Bock et al., 2005). Individuals are continuously attempt to follow and internalize opinions of important reference groups into their own beliefs, thus individuals' attitude is partly group-determined. Additionally, individuals are intend to expose their attitude only when referents support the behavior (Tsai et al., 2012). This leads to:

H3: Positive subjective norms to share knowledge might influence positively on the attitude toward knowledge sharing.

3.2 Platform openness

This paper investigates how the third party developers' perception of platform openness

influence on their knowledge sharing intention. Perceived platform openness is defined as the degree of openness of a mobile platform perceived by third party application developers (Benlian et al., 2015), and it is determined by two dimension, accessibility and controllability.

Perceived accessibility, which is referred to the degree of granting access of the platform perceived by third party developers, is about the how third party developers feel free to access and use the platform technologies and how they understand easily platform technologies and governance decisions of the platform owners (Benlian et al., 2015). Granting access implies lowering the entry barrier of the platform ecosystem (Boudreau, 2012). For example of mobile platform case, both Google and Apple allow third party developers to use their technologies by providing software development kit (SDK) and application program interface (API) (Benlian et al., 2015). It encourages new third party developers to enter the platform ecosystem without any restriction as well as increasing diversity of developer pool (Boudreau, 2012). Based on a wide range of third party developer pool, a developer enable to approach to diverse information, expertise, and communication channels (Cummings, 2004). In other words, diversity of developers driven by granting access provides new opportunities of knowledge sharing (Cummings, 2004). At the same time, platform owners provide guides such as help files, tutorials, and check lists in order to enhance their developers' understandings (Benlian et al., 2015). Information and supports of platform owners facilitate understanding about the goals and policies of the platform as well as similar experiences and background knowledge among third party developers (Chiu et al., 2006). As third party developers share a common knowledge base, improved efficiency of communication among them stimulates active knowledge sharing (Chiu et al., 2006). Therefore, perceived accessibility might be a critical determinant of knowledge sharing of third party developers.

Perceived controllability refers to the perceived controls of third party developers over the application development. It describes how the platform owner devolves and authorizes the controls to third party developers. Unless the controls do not much hinder the innovation of developers, the platform owner is attempt to control the behavior of third party developers to align with their own goal and interests (Tiwana et al., 2010,

Goldbach and Benlian, 2015). Control theory distinguishes control mechanisms into two modes, formal control and informal control (Goldbach and Benlian, 2015). Formal control is based on incentive or penalty system given by the platform owner while informal control is driven by a group of third party developers who shares norms and values (Goldbach and Benlian, 2015). Since this paper focuses on the differences of platform characteristics driven by the platform owner, we consider only formal control modes as a platform openness construct. In a formal control mode, platform owners regulates and limits processes or outputs of third party developers through monitoring and evaluation (Goldbach and Benlian, 2015). Relinquishing controls of the platform owner implies that the platform owner authorizes third party developers to make decision about application development such as features, functionality, design, and implementation of application (Tiwana, 2015), and it leads to increase in perceived controllability of third party developers. For instance, Android allows app developers to decide freely their app's attributes while iOS controls app developer to follow Apple's quality criteria by the review process. Controllability of third party developers causes uncertainty of app development because there are no fixed rules or practices. As the uncertainty increases, knowledge sharing among developers is stimulated in order acquire more external information, share interpretation, and confirm their own works through social interactions (Mehta et al., 2014). Thus, controllability of third party developer might encourage of knowledge sharing.

Perceived platform openness, which is consists of accessibility and controllability aspects, might influence on the subjective norms of third party developers because a platform owner's open strategies change climate of the platform. In the organizational context, climate refers to the common practices, beliefs, and values that organizational members share and follow, and it related to thoughts, feelings and behaviors of the members (Chen and Huang, 2007, Bock et al., 2005). Organizational climate, as a temporal social context, can be manipulated by managers of the organization (Bock et al., 2005). Previous studies show that organizational climate influences perception of knowledge sharing (Chen and Huang, 2007, Bock et al., 2005, Lin and Lee, 2006, Tohidinia and Mosakhani, 2010, Tsai et al., 2012, Fullwood and Rowley, 2017). Likewise, we define a platform climate as

shared practices, beliefs, and values by third party developers, and a platform owner's open strategies change the platform climate by alternating practices, structures, and configurations of the platform. Abovementioned effects of the accessibility and controllability, platform openness establishes a climate where third party developers are willing to communicate and interact each other, which leads to positive subjective norms to share knowledge among third party developers. Therefore, we propose:

H4: Perceived platform openness might have positive effects on subjective norms about knowledge sharing.

3.3. Other motivations of knowledge sharing

Self-efficacy, which refers to one's self-evaluation of the ability to perform a specific task, is a critical motivational factor of a specific behavior (Hsu et al., 2007). An individual with a high self-efficacy is inclined to perform the behavior with confidence (Hsu et al., 2007). Self-efficacy of knowledge sharing behaviors is defined as an individual's self-evaluation of the ability to provide knowledge that is perceived as valuable and useful by others (Chen and Hung, 2010). Self-efficacy is a significant determinant of knowledge sharing behaviors since an individual shares knowledge when he/she has not only desire to share knowledge but also enough capacity to complete it (Lee Endres et al., 2007, Hsu et al., 2007, Bock et al., 2005, Tohidinia and Mosakhani, 2010, Chen and Hung, 2010, Lin, 2007). Especially, self-efficacy plays an important role when exchanged knowledge is practice-related, complex, and expert (Hsu et al., 2007, Lee Endres et al., 2007). Because sharing knowledge of application development requires a certain level of expertise of the knowledge provider, self-efficacy might have an effect on knowledge sharing of third party developers. A third party developer who has high self-efficacy of knowledge sharing are likely to have positive attitude toward knowledge sharing because the developer is attempt to achieve the desired outcome (Hsu and Chiu, 2004).

H5: Self-efficacy of third party developers might lead to a positive attitude toward knowledge sharing.

Furthermore, third party developers with high self-efficacy can more easily understand expectations for knowledge sharing of reference group and comply with the expectation

(Bock et al., 2005). Thus, self-efficacy might indirectly influence on the subjective norms of knowledge sharing.

H6: Self-efficacy of third party developers might lead to positive subjective norms of knowledge sharing.

Reciprocity is the belief that an individual who helps another person will be repaid for the favor by the person (Xu and Li, 2015, Feng and Ye, 2016). It related to an individual's obligation to return the favors receiving from others in the past as well as an expected future benefits from others in return for his or her help (Feng and Ye, 2016, Lin, 2007). Thus, reciprocity, as a sense of mutual indebtedness, encourages to sustain social exchanges among individuals (Xu and Li, 2015, Bock et al., 2005). In the social relationship among strangers when there is no assurance the favor will be returned, the concept of reciprocity is generalized. Reciprocated benefits not only by the direct receiver but also by anyone who is involved in the relationship (Wasko and Faraj, 2005, Feng and Ye, 2016). In this paper, reciprocity of third party developers is defined as a sense of indebtedness related knowledge provided other developers as well as expectation of reciprocal benefits from other developers in return to current knowledge sharing behavior. According to survey of Stackoverflow in 2017, 80 percent of software developers acquires knowledge from other developers through virtual communities or friends network. Experience using knowledge of other developers makes a third party developer to feel indebtedness that the developer has to share knowledge like other developers provides knowledge (Xu and Li, 2015). Additionally, developers expect that their future requests for knowledge will be met in return for their current knowledge sharing (Chen and Hung, 2010). Therefore, perceived reciprocity of third party developers keep sharing knowledge by establishing a positive attitude toward knowledge sharing.

H7: Perceived reciprocity of third party developers might lead to a positive attitude toward knowledge sharing.

Reciprocity contribute to establish mutual beneficial relationships among the group of third party developers (Hsu and Lin, 2008). As third party developers have positive perception of the relationship or social exchange among them, subjective norms to share

knowledge might be strengthened.

H8: Perceived reciprocity of third party developers might contribute to positive subjective norm about knowledge sharing.

Building a good reputation is counted as an important motivational factor of knowledge sharing (Oreg and Nov, 2008, Xu and Li, 2015, Hsu and Lin, 2008). Third party developers exhibit their status, ability, and identity by sharing knowledge (Oreg and Nov, 2008). Through knowledge sharing behaviors, the developers expect receiving respects and gaining status from others (Wasko and Faraj, 2005, Safa and Von Solms, 2016). In addition, these knowledge sharing behavior of a developer gives information for companies or clients who seek and hire a developer, thus knowledge sharing opens further opportunities of advance in careers (Oreg and Nov, 2008). This argument leads to:

H9: Desire to gain reputation might lead to a positive attitude toward knowledge sharing.

In mobile platform ecosystems, competition occurs among third party developers. Platform owners including Google and Apple are provide distribution channels for their developers with centralized markets such as Google Play and App store, every applications is generally delivered to end-users through same market. In addition, the number of developers who enter the market is increased, the competition among developers becomes fierce. In this intense competition, knowledge is a main source of competitive advantages of third party developers (Ghobadi and D'Ambra, 2012, Boudreau, 2012). However, competitiveness derived from knowledge can easily dwindle and be lost by sharing knowledge with other developers because of the characteristics of digital technologies (Ghobadi and D'Ambra, 2012). Digital technology including mobile applications can be reprogrammable, implemented for various functionalities as well as allow processing and transmission of data in a common way (Yoo et al., 2010). Thus, once knowledge is revealed, the knowledge becomes a sort of public goods quickly. In a situation of intense competition, third party developers are more likely to be free rider who make private gains in order to outperform the partners rather than sharing their own knowledge (Ghobadi and D'Ambra, 2012). Moreover, applications are hard to be appropriated by traditional means. Copyrights and patents can protect applications only

from direct code copying or decompilation, not from imitations of visual aspects, functions, and concepts of the applications (Boudreau, 2012). Thus, knowledge sharing in the platform context involves the risk of losing competitiveness by providing valuable knowledge of a developer to their competitors. Consequentially, developers who consider other developers as competitors are likely to take a negative attitude toward knowledge sharing.

H10: A sense of rivalry to other developers might lead to a negative attitude toward knowledge sharing.

4. Methodologies

4.1. Empirical context and Data

This paper investigates the intention of third party developers to share their own knowledge with other developers and motivations behind knowledge sharing intention in the mobile platform context. Since this paper consider platform openness as a critical determinant of knowledge sharing intention, I focus on perception of app developers of Android, which is a representative open mobile platform. Google acquired Android in 2005, and disclosed the source code in order to attract app developers (Appleyard and Chesbrough, 2017). Third party developers use the Android technologies with SDK and API in the official website, named Android Developers, as well as various tools such as Android Studio, Issue Tracker, and Android Community (Benlian et al., 2015). Google also provides a centralized portal for market place of Android app (Holzer and Ondrus, 2011). Based on these open strategies, the market share of Android dramatically increased and surpassed those of iOS (Van Alstyne et al., 2016).

To understand how Android app developers determine the knowledge sharing behavior, I conducted online survey targeting Android app developers. An advertisement with online survey link was posted in a community of Korean developers (<http://cafe.naver.com/aphone>) where more than 60,000 members involved in. 130 responses were collected from 21st April to 10th May in 2018, and only 116 responses

are used as final samples for the analysis after excluding 14 responses answering to every questions in a same number. Brief profiles of the respondents are shown in Table 1. The final sample consists of 51% of male and 49% of female, and average age of the respondents is 32.3 years old. For the developer information, average development experience is 24.4 months. 67% of respondents is hobby developers, 18% of employed developers and 15% entrepreneurs are included in the sample.

Gender	Male	59
	Female	57
Age (year)	20-29	43
	30-39	60
	40 or more	13
Development experience of Android applications (month)	6 or less	28
	7-12	24
	13-24	16
	25-36	17
	37 or more	31
Professional background	Employed developers	21
	Entrepreneurs	17
	Hobby developers	78
Total		116

Table 1. Respondent Profiles

Before asking questions about the intention of knowledge sharing in the future, I checked whether the developers have previous knowledge sharing experiences. 59% of respondents answered that they have shared knowledge 3.2 times per a month on average. Community is a most popular means for knowledge sharing, and about 20% respondents are also use blog posting and face-to-face conversion. The respondents shared various kinds of knowledge such as contents and performance their own app, manuals and methodologies, development experiences, know-how, and trend information. Details are presented in Table 2.

Knowledge sharing experience	I have shared knowledge	68
	I have NOT shared knowledge	48
If you have shared knowledge...		
Average Frequency (per month)		3.8
How to share knowledge	Blog posting	23
	Communities (Board, Discussion, Q&A, and etc.)	51
	Face-to-face conversation	20
	Mail	14
	Telephone call	15
	Giving lecture	5
Kinds of knowledge you shared	Contents and performance of my app	26
	Manuals and methodologies	36
	My app development experiences	32
	Trend information from news, journal, and articles	29
	My know-how	33
	Know-where and Know-who	32
	My expertise from education or training	22

Table 2. Previous Knowledge Sharing Experiences of the Respondents

Additionally, I confirmed whether the developers perceive the difference of knowledge sharing behaviors by platforms. 76% of respondents answered that the degree of knowledge sharing is different according to the platform, and 92% of them think that the most active platform for knowledge sharing is Android. In order to understand this difference, I explore the motivational factors of third party developers of Android.

4.2. Measurement items

This paper employed measurement items from previous studies and revised the items to reflect the context of knowledge sharing of third party developers. Every measurement items is followed in Table 3. The measurement items is rated on 7-point Likert scale ranging from strongly agree to strongly disagree.

Knowledge sharing intention, a major interest of this paper, is measured by 4 items related to individuals' willingness to make efforts for knowledge sharing given by Lin (2007) and to future plans and possibilities proposed by Tohidinia and Mosakhani (2010). Theory of reasoned action focuses on attitudes and subjective norms as determinants of knowledge sharing intentions. Attitudes toward knowledge sharing derived by Lin (2007) consist of 4 items with emotional words including pleasant, valuable, beneficial, and agreeable. Subjective norms is related to the beliefs of whether referents are approve knowledge sharing behaviors or not (Hamari and Koivisto, 2015) and to motivation to comply with referents' opinion (Bock et al., 2005).

As a critical motivational factor of knowledge sharing of third party developers, I focus on their perception of platform openness. Items of the overall platform openness are employed from Benlian et al. (2015) and Wu and Chen (2017). Platform openness might be understood with two aspects, accessibility and controllability. Accessibility is related to whether third party developers feel free to access, use, and revise Android technologies (Alraimi et al., 2015) as well as how they easily understand the technologies (Benlian et al., 2015). Controllability is measured by overall controllability over app development activities (Hsu and Chiu, 2004) and by decision rights of third party developers to functionality, design, and user interface of apps (Tiwana, 2015).

The research model includes other motivational factors from previous studies. Items of reputation, reciprocity, and self-efficacy are employed from literatures related to knowledge sharing in virtual communities (Hsu et al., 2007, Wasko and Faraj, 2005, Xu and Li, 2015) and organizations (Lin, 2007, Tohidinia and Mosakhani, 2010). A sense of rivalry to other developers is measured by items from Nguyen et al. (2017) focusing on knowledge sharing among cross-functional teams and from Lin et al. (2010) researching on competition in the organizations.

Construct		Items	Reference
	KSI1	I will try to share knowledge with other app developers.	Lin (2007), Tohidinia &

Knowledge sharing intentions	KSI2	I will always make an effort to share knowledge with other app developers.	Mosakhani (2010)
	KSI3	I am likely to share my knowledge with other app developers in future.	
	KSI4	I plan to share my knowledge with other app developers.	
Perceived platform openness	PPO1	Android is open to app developers	Benlian et al. (2015), Wu & Chen (2017)
	PPO2	I have the freedom to develop Android apps.	
	PPO3	Google supports app developments of Android developers.	
Accessibility	AC1	I can access technologies of Android easily (API, SDK etc.).	Alraimi et al. (2015), Benlian et al. (2015)
	AC2	I feel free to use and revise technologies of Android.	
	AC3	I feel free to combine technologies of Android with other to develop applications.	
	AC4	App developers can easily understand the technologies and process of developing an application of Android.	
Controllability	CT1	Whether or not I develop mobile app using Android is entirely up to me.	Tiwana (2015), Hsu & Chiu (2004)
	CT2	Whether I develop mobile app using Android is under my control.	
	CT3	I am primarily responsible for making decisions about functionality of my Android app.	
	CT4	I am primarily responsible for making decisions about design of my Android app.	
	CT5	I am primarily responsible for making decisions about user interface of my Android app.	

Attitude toward knowledge sharing	AT1	My knowledge sharing with other developers is pleasant.	Lin (2007)
	AT2	My knowledge sharing with other developers is valuable.	
	AT3	My knowledge sharing with other developers is beneficial.	
	AT4	My knowledge sharing with other developers is agreeable.	
Subjective norms	SN1	App developers who influence my attitudes would recommend to share knowledge.	Hamari & Koivisto (2015), Bock et al. (2005)
	SN2	App developers who are important to me would think positively of me sharing knowledge.	
	SN3	App developers who I appreciate would encourage me to share knowledge.	
	SN4	Generally speaking, I accept and carry out other developers' decision even though it is different from mine.	
	SN5	Generally speaking, I respect and put in practice other developers' decision.	
Reputation	RP1	If I share my knowledge with other developers, I will gain more recognition and respect.	Hsu et al. (2007), Wasko & Faraj (2005)
	RP2	I feel that knowledge sharing improves my status in the profession.	
	RP3	I share knowledge to improve my reputation in the profession.	
Reciprocity	RC1	When I share my knowledge with colleagues, I believe that my future requests for knowledge will be answered.	Lin (2007), Xu and Li (2015)

	RC2	I feel a personal obligation to share knowledge because I use knowledge from other developers.	
	RC3	If I receive useful knowledge from other developers, I should contribute in return.	
Self-efficacy	SE1	I am confident in my ability to provide knowledge that other developers consider valuable.	Lin (2007), Tohidinia & Mosakhani (2010)
	SE2	My knowledge sharing would help other developers to solve their problems.	
	SE3	My knowledge sharing would increase productively in other developers.	
Rivalry	RV1	App developers who use my shared knowledge are my competitors.	Nguyen et al. (2017), Lin (2010)
	RV2	If I share knowledge, I can lose competitiveness to other app developers.	
	RV3	Protecting my knowledge seemed to be a way of life in competition with other developers.	
	RV4	Competition among app developers is a win-lose competition.	

Table 3. Measurement Items

5. Results

To test the research model, structural equation modeling (SEM) based on partial least squares (PLS) is employed. PLS method requires relatively minimal sample size as well as generous assumption in sample distribution than alternative SEM methods (Fornell and Cha, 1994). I used SmartPLS 3.0 to analyze the survey data.

5.1. Measurement model

To confirm the consistency of measurement, reliability of each measurement items and

constructs are examined as shown in Table 4. Factor loading for every items are above 0.7, which means that every item shows proper level of reliability (Barclay et al., 1995). All constructs are satisfied with the reliability criteria, exceeding 0.7 of Cronbach's alpha and 0.8 of composite reliability (Henseler et al., 2016). Furthermore, two types of validity, convergent validity and discriminant validity, are tested for the research model. Average variance extracted (AVE) of all constructs are larger than 0.5, threshold value indicating convergent validity. To assess the discriminant validity, Fornell-Lacker criterion is shown in Table 5 as well as Heterotrait–monotrait ratio (HTMT) is presented in Table 6. Since the square root of AVE of every construct exceeds the correlations with other constructs in the Fornell-Lacker criterion, the model has proper discriminant validity (Henseler et al., 2016). Additionally, every HTMT ratio is less than 0.9, and it supports that the model has enough discriminant validity. Therefore, the measurement model demonstrates proper level of reliability and validity.

Construct	Item	Factor Loading	Cronbach's α	Composite Reliability	AVE
Knowledge sharing intentions	KSI1	0.924	0.933	0.952	0.83
	KSI2	0.931			
	KSI3	0.901			
	KSI4	0.892			
Platform openness	PPO1	0.823	0.808	0.887	0.72
	PPO2	0.827			
	PPO3	0.899			
Accessibility	AC1	0.857	0.902	0.931	0.77
	AC2	0.891			
	AC3	0.893			
	AC4	0.874			
Controllability	CT1	0.843	0.876	0.91	0.67
	CT2	0.746			
	CT3	0.819			
	CT4	0.819			

	CT5	0.858			
Attitude toward knowledge sharing	AT1	0.925	0.909	0.937	0.79
	AT2	0.911			
	AT3	0.934			
	AT4	0.777			
Subjective norms	SN1	0.824	0.839	0.886	0.61
	SN2	0.853			
	SN3	0.799			
	SN4	0.7			
	SN5	0.721			
Reputation	RP1	0.884	0.793	0.875	0.7
	RP2	0.9			
	RP3	0.719			
Reciprocity	RC1	0.875	0.855	0.912	0.78
	RC2	0.889			
	RC3	0.878			
Self-efficacy	SE1	0.9	0.876	0.924	0.8
	SE2	0.879			
	SE3	0.907			
Rivalry	RV1	0.891	0.91	0.935	0.78
	RV2	0.899			
	RV3	0.895			
	RV4	0.852			

Table 4. Reliability and Convergent Validity

	KSI	PO	AC	CT	AT	SN	RP	RC	SE	RV
KSI	0.912									
PO	0.457	0.850								
AC	0.521	0.618	0.879							

CT	0.414	0.552	0.662	0.818						
AT	0.720	0.424	0.449	0.403	0.889					
SN	0.700	0.628	0.636	0.522	0.666	0.782				
RP	0.643	0.424	0.424	0.416	0.529	0.623	0.838			
RC	0.544	0.328	0.401	0.549	0.527	0.542	0.544	0.88		
SE	0.566	0.422	0.474	0.532	0.527	0.576	0.663	0.455	0.895	
RV	0.382	0.249	0.199	0.418	0.167	0.401	0.458	0.307	0.489	0.885

Note. Diagonal elements are the square roots of the AVE. KSI: knowledge sharing intentions, PO: platform openness, AC: accessibility, CT: controllability, AT: attitude toward knowledge sharing, SN: subjective norms, RP: reputation, RC: reciprocity, SE: self-efficacy, RV: Rivalry

Table 5. Fornell-Lacker Criterion

	KSI	PO	AC	CT	AT	SN	RP	RC	SE	RV
KSI										
PO	0.522									
AC	0.575	0.705								
CT	0.454	0.648	0.738							
AT	0.777	0.496	0.501	0.452						
SN	0.787	0.765	0.735	0.608	0.76					
RP	0.739	0.499	0.486	0.489	0.589	0.752				
RC	0.606	0.39	0.457	0.639	0.602	0.651	0.691			
SE	0.626	0.494	0.539	0.61	0.588	0.659	0.794	0.52		
RV	0.412	0.295	0.224	0.484	0.172	0.451	0.585	0.341	0.551	

Table 6. Heterotrait–monotrait ratio (HTMT)

Note. Diagonal elements are the square roots of the AVE. KSI: knowledge sharing intentions, PO: platform openness, AC: accessibility, CT: controllability, AT: attitude toward knowledge sharing, SN: subjective norms, RP: reputation, RC: reciprocity, SE: self-efficacy, RV: Rivalry

5.2. Structural model

Hypotheses proposed in the research model were tested with PLS, and almost hypotheses are supported as depicted in Figure 2. First, theory of reasoned action is reconfirmed in

the results which support hypothesis 1, 2, and 3. Knowledge sharing intentions is positively encouraged by subjective norms ($\beta=0.397$, $p<0.001$) and attitudes toward knowledge sharing ($\beta=0.455$, $p<0.001$). Both determinants explain 60.6% of variance in knowledge sharing intention. Subjective norms also have indirect effects on knowledge sharing intention by leading to positive attitudes toward knowledge sharing ($\beta=0.471$, $p<0.001$). Second, accessibility and controllability are positively associated with platform openness, and these two aspects explain 41.8% of variance in platform openness. Platform openness induces positive subjective norms ($\beta=0.422$, $p<0.001$), which supports hypothesis 4. Third, motivational factors from previous studies show mixed results, and significant results are found except for hypothesis 9. Self-efficacy contributes to increase in intention to share knowledge by positively influencing on subjective norms and attitudes. Hypothesis 5 and 6 are supported with coefficients corresponding 0.270 and 0.222, respectively. Reciprocity related to hypothesis 7 and 8 also has a positive effects on attitude ($\beta=0.198$, $p<0.05$) as well as it leads to positive subjective norms about knowledge sharing ($\beta=0.422$, $p<0.01$). However, reputation does not show a significant effect on attitudes, which fails to support hypothesis 9. It implies that reputation is not important motivation for third party developers to share knowledge. Finally, a sense of rivalry to other developers hinders the knowledge sharing by inducing negative attitudes toward knowledge sharing ($\beta= -0.229$, $p<0.05$), supporting hypothesis 10.

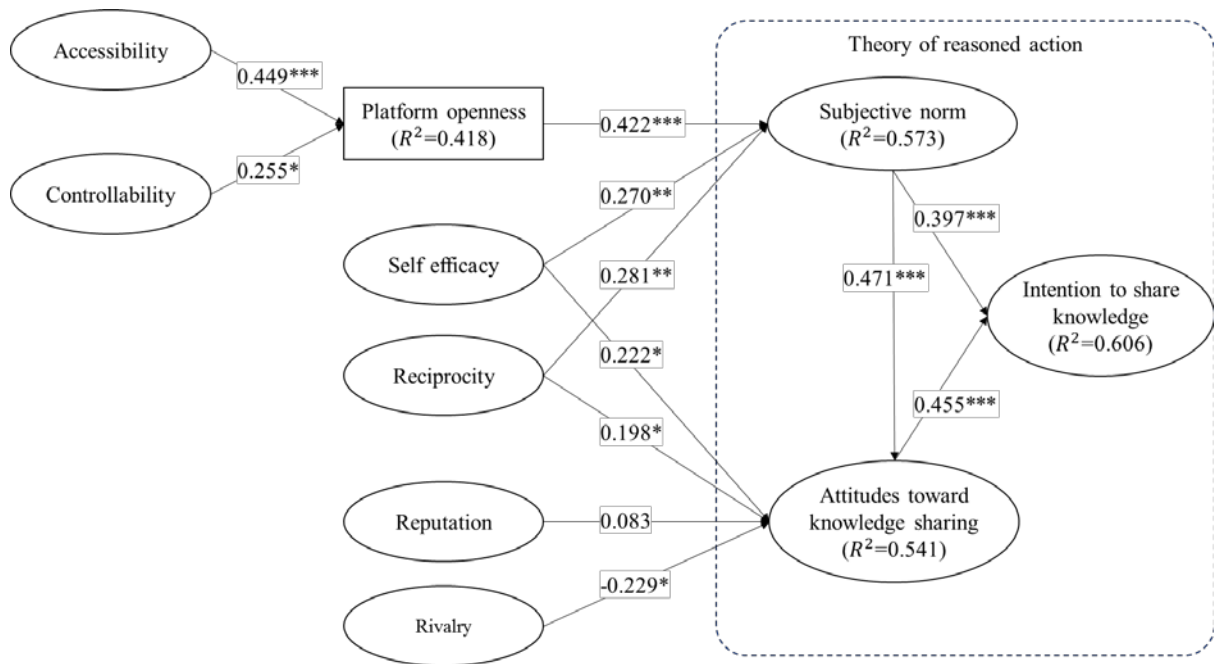


Figure 2. Results of hypothesis testing

Note. *: $P < 0.05$, **: $P < 0.01$, ***: $P < 0.001$

6. Conclusion & Discussion

This paper investigates the motivation of third party developers to share knowledge in the mobile platform context. As a theoretical background, theory of reasoned action provides descriptions of the intention of volitional behaviors including knowledge sharing. In the theory, the intention of knowledge sharing is determined by an individual's attitudes and subjective norms of referents. Diverse motivational factors can be influenced on the knowledge sharing intention through attitudes and subjective norms. The influences of motivational factors are different according to the context of knowledge sharing. Previous studies have focused on the knowledge sharing in organizational or virtual community context. This paper researches on the knowledge sharing intention and distinctive motivational factors in the mobile platform context.

Especially, this paper assumes that platform characteristics derived by the platform owner's strategic decisions can be a determinant of knowledge sharing of third party developers. Among diverse characteristics of platform, platform openness is considered

as a critical environmental factor of knowledge sharing intention. Platform openness is defined as multidimensional constructs with accessibility and controllability. Accessibility represents how third party developers can easily use and understand technologies of the platform. Controllability describes how they can make a decision for their own application development without intervention of the platform owner. The result shows that third party developers perceive accessibility and controllability as separated concepts with proper level of discriminant validity. Both constructs contribute to overall platform openness positively, and the platform openness induces positive subjective norms of Android developers about knowledge sharing. Previous studies describe that organizational climates induces specific subjective norms of the organization. Likewise, platform characteristics derived from platform openness establishes a platform climates among developers which favorable to knowledge sharing. Therefore, platform openness is a crucial determinant of subjective norms about knowledge sharing of third party developers.

Furthermore, knowledge sharing in the platform context is different from those in the organizational context because the relationship among third party developers is close to direct competitors. Since every applications are displayed and delivered through the centralized markets, there is a fierce competition among third party developers. At the same time, third party developers in the platform ecosystem does not pursue common goals and interests while members in the organization collaborate and share knowledge for achieving the common goal of the organization. The developers are primarily concern to their individual interest such as the success of application, and they are inclined to appropriate resources related to their competitiveness. Because knowledge is a valuable resource for competitive app development, the developer who are concerned about competition might hesitate to share knowledge. This paper supports this hypothesis by the result that the developers who have high sense of rivalry to other developers are likely to show negative attitudes toward knowledge sharing. Hence, rivalry of third party developers hinders knowledge sharing.

Other motivational factors from previous studies on knowledge sharing show mixed effects in the platform context. Self-efficacy is a prerequisite of knowledge sharing

behavior because it implies whether the developer has an enough capability to share knowledge with confidence. In the platform context, self-efficacy of developers stimulates knowledge sharing by inducing positive subjective norms and attitudes toward knowledge sharing. Since knowledge about app development is expert and practical, self-efficacy is an important determinant of knowledge sharing in the platform context. Reciprocity also motivates to continuous social exchanges among third party developers based on indebtedness. The result shows that reciprocity encourages knowledge sharing of third party developers through positive subjective norms and attitudes. It implies that a virtuous circle among third party developers to help each other through knowledge sharing is established. Thus, results of self-efficacy and reciprocity are consistent with previous studies. However, reputation which is considered as a critical motivation in virtual community context does not have a significant effect on knowledge sharing. It indicates that incentives of reputation might not encourage developers to share knowledge. Reputation is classified as an extrinsic motivation of knowledge sharing (Xu and Li, 2015, Safa and Von Solms, 2016). Generally, extrinsic motivations initiated by external forces stimulate only stereo typed works with less creativity, thus it will have minor influences on knowledge sharing (Kwok and Gao, 2005). Furthermore, Xu and Li (2015) states that only pure extrinsic motivations such as monetary rewards and promotions stimulate knowledge sharing behaviors in the short term.

This paper provides several academic and practical implications. First, this paper is an initial research exploring the relationships between the knowledge sharing intention of third party developers and platform openness. It shows that platform characteristics driven by the platform owner' openness strategies can change the knowledge sharing intention and that platform openness enhance knowledge sharing. Thus, the platform owner can open their platform in order to stimulate knowledge sharing, thereby increasing generativity of the platform. Second, comprehensive framework for knowledge sharing in the platform context is provided in this paper. To understand knowledge sharing of developers, a competitive relationship among the developers has to be considered. Additionally, self-efficacy and reciprocity boost knowledge sharing while reputation is not effective in the platform context. Third, multidimensional constructs of platform

openness suggest concrete action plans for the platform owner who are attempt to open their platform. Since the platform openness is a general and ambiguous concept, platform owners have difficulty in designing specific open strategy. This study describes the platform openness based on two constructs, accessibility and controllability. It implies that platform owners can open their platform by allowing to access and revise the platform technologies and to authorize decision right for application to developers.

There are several limitations in the paper. First, this paper investigates a single platform, Android. Since the platform developers' perception can be altered according to degree and manner of platform openness, comparative study of platforms with different open strategies is required to validate the research model. Second, knowledge sharing behaviors of third party developers might changes along with the maturity of platforms. In the initial stage of a platform, developers are likely to acquire and exchange basic knowledge provided by platform owners or a few frontier developers. As the platform becomes mature, knowledge sharing is complexed and specialized based on the accumulated knowledge base and a wide developer pools. Longitudinal researches can provide implication about changes in the kinds of knowledge they share, the means and motivation of knowledge sharing. Third, PLS methodologies only test linear relationships among constructs. However, knowledge sharing intentions and motivational factors can have non-linear relationships. For example, Boudreau (2010) described that platform openness has the relationship of inverted U-shape with developers' innovation. According to Aghion et al. (2005), intensity of competition also has a specific optimal point to vitalize the innovation. Therefore, additional researches to examine the non-linear relationships among constructs can be conducted with other methodologies such as Warp PLS.

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