

Commercialization of Open Software, Knowledge Flow, and Patents

Shixuan Yu[1(✉)] and Ping Yu[2]

[1] Shanghai Institute of Technology, Shanghai 200030, China
yushixuan8@163.com
[2] Communication University of China, Beijing 100024, China

Abstract. Open source communities as large-scale paradigm innovations have attracted a lot of attention from scholars. In this paper, we analyze the possible effects that software companies' participation in open source communities can have on corporate patents through knowledge flow theory. Technological innovation resulting from the acquisition of technical knowledge by open source communities shortens the cycle of corporate technological innovation. However, since firms' technological innovation activities can only be imitations and follow-the-flow innovations, they may sometimes cause the failure of firms' technological innovation.

Keywords: Open software · Commercialization · Knowledge flow · Patents

1 Introduction

The early practices of the open source community originated from well-known open source software projects such as Linux and Apache. Following the great success of these open source projects, open source software (OSS) has attracted the attention of different academic fields. Some studies have focused on the motivations that drive users and developers to contribute to OSS projects [1], how the innovation process works [2], and the governance issues of the OSS community [3]. Open source software (OSS) is attracting commercial interest from a growing number of companies. The best known examples are IBM, Sun Microsystems, and Oracle, all of which have begun to invest in and legitimize Linux for enterprise applications [4]. As early as the first quarter of 2005, Novell had already realized $44 million in Linux-related product revenue, or 15% of its total sales for the same period. Other companies, such as Red Hat, have specialized as OSS distributors, aggregating, integrating and optimizing the latest software code offered by the OSS community. So why should for-profit companies get involved in the commercialization of OSS products?

Since becoming commercialized [5], another line of research on OSS has focused on for-profit companies that work with the OSS community [6, 7], which companies use to ensure the intellectual property protection mechanisms to ensure their return from the open business model [1, 8] and the competitive dynamics introduced by OSS [9].

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Although the potential benefits of widespread OSS adoption for participants have been largely established [8], there is still a lack of empirical evidence on the impact that OSS commercialization may have on patents of for-profit companies. According to Chesbrough [10], the real social impact of an innovation only arrives after it is commercialized. In an open innovation model, IP does not languish; it creates value, either directly or via licensing or other inside-out mechanisms. In a knowledge-based economy, knowledge capital is a more important source of value creation than are natural or capital resources. In such an economy, technology innovation is achieved through active knowledge flow between knowledge actors. Thus, it is important for firms to establish a strategy considering knowledge flow to improve innovation ability through the use of knowledge coming from open source [11, 12]. Many innovative firms have use a great variety of external sources to create new innovations and sustain existing ones [11]. One of the key challenges of open innovation is 'motivating outsiders to supply an ongoing stream of external innovations' [13]. In addition, Nelson and Winter [14] mentioned that one characteristic of innovation is commercialization of the invention.

Therefore, when firms commercialize, it will inevitably have an impact on innovation. Based on the knowledge-based theory of the firm, this paper first combines knowledge flow and open source communities, briefly discusses the impact of commercial participation in open source communities on patents, and argues that this impact is mainly reflected in technology innovation mode and cycle. Therefore, when firms try to profit from open source communities, it inevitably have an impact on internal innovation. Based on the knowledge-based theory of the firm, this paper combines knowledge flow and open innovation literature to briefly explore the impact of business participation in open source communities on patents, and argues that this impact is mainly reflected in technology innovation mode and cycle.

2 Knowledge Management and Open Innovation

2.1 Innovation and Open Source

According to Chesbrough [15], open innovation can utilize inbound and outbound knowledge flows to facilitate the growth of their innovation outputs. There are two stages: utilizing external innovations internally, and externally commercializing internal innovations [11]. The former is the basis for commercial companies to use open-source communities to develop commercial software. One of the important arguments is that companies can benefit from individual participants outside the company. Utilizing external innovations internally can be seen as a process includes three phases: obtaining, integrating, and commercializing external innovations [13].

The acquisition of external resources for open innovation includes customers, competitors, consumer public research institutions, universities and other types of organizations, while simultaneously using creative methods to exploit a firm's resulting IP [11]. Enterprises also enter professional fields beyond their boundaries through various mechanisms, including license agreement alliances, joint ventures, and informal social interactions. When the new technology reduces the transmission cost, promotes

the rapid exchange and dissemination of information, and expands the scope of dissemination to potential participants, the diffusion characteristics of the innovation process are particularly obvious.

For new products,there are significant trade-offs between innovation speed, development costs, and competitive advantage for relying on external rather than internal learning [16]. Therefore, when the existence of external knowledge cannot be incorporated into innovation activities by the enterprise, the enterprise will lose huge profits. Only after the company's external knowledge is absorbed, can the company begin to adopt further measures to promote internal innovation results, such as licensing of IP, patent pooling and so on. Open innovation can reflect a shift in how companies manage and use their IP.

Open source software is an important output of the open source community in the software industry, and it is also a practice in open innovation. Compared with patent software, OSS users have the authority to modify enhance and extension software by a wide range of software licenses. In contrast, patented software strictly protects the source code. Using communication technology, participants in open-source projects can jointly create advanced software solutions and share new results in a collective manner within the community. Joining the open-source community may ensure that companies continue to produce new results.

2.2 Knowledge Flow and Open Innovation

From the perspective of knowledge capital, knowledge management influences the change of organizational management model with the development of the knowledge economy era, that is, the focus on product process management in the past has changed to the current focus on the management of enterprise knowledge capital and human capital. For the definition of knowledge management, most scholars focus on explaining knowledge management from the knowledge flow process. Alavi and Leidner [17] believes that knowledge management is the process of knowledge creation, knowledge storage, knowledge transfer and knowledge application for organizational knowledge capital. Knowledge management is an activity that enhances the competitiveness of enterprises through screening and acquiring and synergizing knowledge within a hierarchical organization.

Open innovation focuses on the acquisition and development of internal and external knowledge, and its essence is to comprehensively utilize the convenient knowledge flow across the internal and external organizations to accelerate the process of internal knowledge innovation. Therefore, the process of open innovation is the process of management and application of knowledge flow. In the knowledge network formed by enterprises, based on the embedded perspective, knowledge is always in a dynamic flow. This kind of knowledge flow usually has two directional vector interpretations. From the horizontal vector, the uneven distribution of knowledge among knowledge subjects and the higher requirements of specialized knowledge for carriers are the manifestations of knowledge heterogeneity. The internal demand and market demand it brings have led to the flow of knowledge among subjects. In terms of the vertical vector, the knowledge potential difference caused by the gap in the knowledge stock between subjects leads to

the directional flow of knowledge due to the difference in social division of labor and resource endowments.

The value created by the flow of knowledge does not directly come from intellectual capital, but from the interaction between elements of intellectual capital. Inter-organizational knowledge flows is an important factor for organizational innovation and new knowledge creation as it can increase company's innovation capabilities what in turn increases its competitive advantage. The commercialization of open source software involves two organizations of different nature: open source communities and enterprises. Therefore, it is particularly important to study the knowledge flow between them. According to previous research [18], knowledge flow can be summarized into 4 stages: knowledge acquisition, knowledge transfer, knowledge integration, knowledge creation and application.

Knowledge Acquisition

Knowledge acquisition means that enterprises provide a knowledge base for open innovation through searching, absorbing and sharing internal and external knowledge, and lay the foundation of knowledge source for the next stage of knowledge transformation. The sources of knowledge flow in the open innovation framework can be diversified, such as upstream suppliers, university scientific research institutions and even competitors. These knowledge flows enter the knowledge inventory through absorption and sharing, and increase the knowledge stock of enterprises. Knowledge acquisition itself means that companies must establish a powerful search capability mechanism when searching for knowledge sources, so as to quickly find complementary knowledge or enhance knowledge. It is worth noting that in open innovation, most companies focus too much on searching "Opening up" knowledge and neglecting the development of the enterprise's own knowledge. The enterprise itself has a large amount of tacit knowledge, which is usually expressed as the intellectual capital of employees. After the acquisition of external knowledge, the enterprise and employees absorb and internalize their own knowledge storage, Knowledge sharing plays an intermediary role in this process.

Enterprises can benefit from personal creativity outside the enterprise, but the inflowing ideas and innovations from outside are not spontaneous, and new strategic working methods must be adopted to match the behavior of the enterprise with the resources and capabilities available from the external environment. In this context, free and open source software companies are an extreme example because innovations are provided by individuals who merge into the community, which means that traditional methods (such as contracts) to deal with other companies' external inputs are no longer suitable.

Focusing uncontrollably on innovations that benefit from external sources is difficult to be productive. For innovative activities, enterprises need to control many elements in the innovation network to a certain degree. Openness is beneficial, and this benefit decreases with the intervention of too many external sources of innovation. How to coordinate external knowledge to make the company open and get enough feedback to survive is a challenge.

If firms want to use external knowledge, companies need to know where the knowledge exists how to obtain it, and how to use it later. In order to deal with this, companies need to develop internal expertise to identify and absorb external results. Although absorptive capacity initially focused on identifying and evaluating possible external

knowledge, in the future it will focus on how companies recognize and understand, absorb and apply external knowledge. Absorptive capacity shows that the external assimilation knowledge partly depends on the internal knowledge, because it simultaneously guides search behavior and the possibility of evaluating and using resources.

Knowledge Transfer
Knowledge transfer is the process of transportation and transformation of knowledge resources. Al-Laham et al.[19] believes that knowledge has time value, and the value of knowledge gradually decreases with the passage of time, which will also bring about the shrinking of the organizational knowledge inventory.“ From a formal point of view, knowledge transfer is the process of tacit knowledge through coding and The process of the diffusion and externalization of the formal channels of the organization; from the perspective of knowledge flow, knowledge transfer is the transfer of the acquired knowledge source to the individual or department of knowledge demand: from the perspective of external performance, the transfer of knowledge at the individual level is generally through communication and other informal channels are used, and department-level knowledge transfer is usually achieved through formal channels such as meetings and teamwork.

Knowledge Integration
Knowledge integration refers to the organization, reorganization and interpretation of existing knowledge in order to create new knowledge and maximize knowledge collaboration. This process is usually manifested as the storage, fusion and combination of coded knowledge. The knowledge integration process contains the transformation and fusion of individual knowledge to collective knowledge. Through multiple combinations of different unit knowledge, the stock and quality of enterprise knowledge are improved. Knowledge integration is a cyclical process. In the internal network composed of nodes and subnets within the enterprise, knowledge integration makes the node knowledge diffuse into subnet knowledge through the network, and the subnet knowledge is accepted by the nodes. This process makes the scattered individual knowledge integrated into Organize collective knowledge. However, it should be noted that knowledge integration is often through the organization’s traditional knowledge fusion mechanism, that is, the manager’s conventions and commands, which will lead to the blind obedience of knowledge subjects and the decline of innovation performance.

Knowledge Creation and Application
Knowledge creation and application are the embodiment of “knowledge creation value”, the result of the entire knowledge process and open innovation. From the perspective of knowledge stock, through the early knowledge acquisition, transfer and integration, the knowledge stock at this time is compared with the acquisition The time has dropped drastically and shows a high degree of coding and specialization. At the same time, the flow rate has been relatively accelerated, forming a process of knowledge appreciation. This knowledge appreciation is not linear and horizontal, but a spiral increase. In addition, the value of knowledge creation and application is reflected in the innovation of enterprises. Performance and innovative products are the commercialization and marketization of knowledge. Through the analysis of the knowledge flow process in open innovation, we

can clearly see a flow chain. The generation power of the knowledge chain is driven by the subjective demand of the knowledge flow and the knowledge potential difference, and the object of the knowledge chain is the knowledge flow itself. In this process, due to the weakening of organizational boundaries and the development of network technology, knowledge will flow out at every stage of the chain. It mainly includes two parts. One part is the knowledge that cannot be identified and discovered in time during the knowledge acquisition stage and cannot meet the innovation requirements, and the other part is the knowledge loss caused by the phased knowledge output.

In the stage of knowledge acquisition and sharing, enterprises focus on the acquisition and absorption of external knowledge sources. The risk factors of the knowledge flow process in this process lie in the knowledge object, the knowledge subject, and the internal and external environment of knowledge. In the stage of knowledge transfer and integration, companies pay attention to knowledge classification, knowledge transportation and integration of acquired knowledge. The flowing risks of this process are reflected in the paradox of knowledge value, the influence of organizational structure, and the formalization and informalization of internal communication channels within the organization. Influence. In the output stage of knowledge innovation, that is, the stage of knowledge creation and application, the risk of knowledge flow comes from the influence of the organization's control and coordination mechanism, corporate culture and external environment.

3 Knowledge Flow and Commercialization of OSS

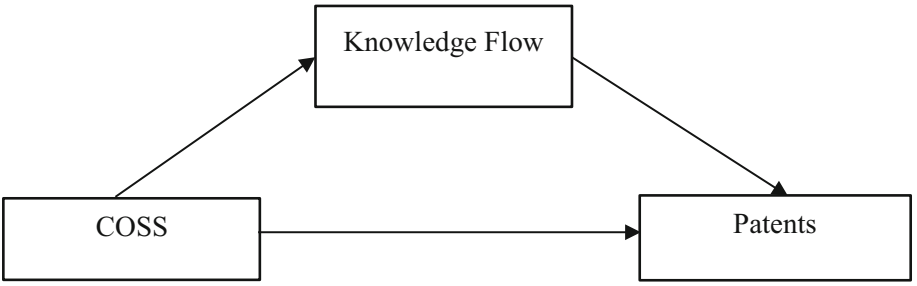

Fig. 1. A theoretical model

3.1 Open Source

In order for commercial companies to better benefit from the open source community, we need to first clarify the characteristics of open source. First, it can reduce transaction costs by licensing agreements. Second, open source contributes to indirect returns investment of firms on different vertical positions. For instance, companies downstream in the supply chain (middleware, applications, hardware, and services) often have access to resources that were previously protected in part by the applicability regime through open source

systems. In addition, companies upstream in the supply chain can benefit from complementary products by increasing the speed of diffusion of industry standards through open source for non-core Technologies [8, 20]. Third, open-source system enables firms to obtain expert skills according to its needs (Fig. 1).

The disadvantage of open source communities mainly comes from the lack of binding contracts between participants. First of all, this leads to unstable innovation output. The output of the open source community depends largely on the experience and skill set of potential contributors and the activity of the contributors. In addition, when a project's major contributors are hired by closed source firms, turning the public outcome of open source into a private product, it may put the project, its members and users at risk.

3.2 OSS and COSS

OSS has reemerged as a mode for developing and organizing software innovation. Firms can respond to such a change in the software development process in different ways: by adjusting to, resisting, or supporting it [20]. Currently, more and more profitable companies choose to publish source code and release open source projects on open source hosting platforms, which is a profitable strategy. First, profitable companies can enhance their innovation efficiency by reducing R&D risk. Second, open source can guarantee a certain level of R&D investment recovery. For situations without considering the participation of commercial companies in the open source community, the success factors depend on the severity of the license, the attractiveness of the community, and the quality of the software. The main differences between commercial companies involved in open source projects are the R&D effort, organizational goals and management mechanisms.

R&D mastery can affect the attractiveness of open source communities. Companies need to make a trade-off between relying on external developers and internal developers, and develop a relevant community attractiveness strategy. In addition, because companies rely to some extent on employees as the R&D anchor, this can lead to projects backed by a stable R&D force that guarantees the quality of open source software.

Organizational goals can influence the severity of the license. Commercial open source projects need to choose the right license both to ensure the open status of the project and to seek revenue streams as well as to maintain the unique competitiveness of the enterprise. In addition. Organizational goals can also have an impact on the attractiveness of the open source community. Furthermore, organizational goals can have a significant impact on the quality of the open source community. Companies will certainly promote the proliferation and visibility of open source projects first in order to make profits.

The governance mechanism first has a great impact on the severity of the license. Commercial companies choose their licenses based on their strategy, and at the same time need to consider the level of acceptance of their licenses by users and volunteer developers in the community. Second, governance mechanisms can have an impact on the attractiveness of open source communities. Companies cannot control the community by means of power, and they cannot make the community resistant to users and volunteers. Finally, governance mechanisms have a significant impact on the quality factor of open source software. Companies control open source projects and can therefore position them for high quality output.

3.3 COSS, Knowledge Flow and Patents

According to the knowledge-based theory of the firm, when a commercial firm participates in an open source community, there is a high probability that the knowledge absorbed from the community will affect the firm's patent output by increasing the firm's ability to innovate.

Patent rights transfer the rights to exclude others from using the technology but do not transfer the usage rights of the technology to the patent holder [21]. It has been argued that a large portfolio of software patents can be a complementary asset that favors the commercialization It has been argued that a large portfolio of software patents can be a complementary asset that favors the commercialization of OSS products [20]. However, little research has been done to examine how commercial firms influence their patent portfolios through participation in the open source community and what factors influence this relationship.

When we combine the knowledge flow process with the contributors involved in the open source projects distributed by the enterprise in the hosting platform, we are able to identify a number of factors within the enterprise related to R&D output that may be influenced by the open source community. First, when employees of a commercial enterprise interact with development engineers outside the enterprise through projects distributed by the enterprise in an open source hosting platform, they gain knowledge related to open source projects in addition to other tacit knowledge. The process of tacit knowledge manifestation can have an impact on technical knowledge management process other than the current open source project. Secondly, programmers involved in open source projects generally develop better communication skills and are therefore able to facilitate knowledge absorption through iterative confirmation when integrating knowledge acquired from external sources. Finally, programmers who participate in open source projects generally develop a better sense of cooperation, and therefore partially increase the frequency of knowledge sharing in a particular department within the enterprise.

The knowledge acquired by software companies from the open source community is technical knowledge. Technical knowledge from outside the enterprise is imported into the enterprise and influences the innovation activities of the enterprise. The technical knowledge outside the enterprise can be divided into two types, explicit technical and invisible technical knowledge, according to the degree of coding. Explicit technical knowledge mainly includes published scientific and technical literature, technical standards, patents and unpublished scientific and technical literature, and internal company reports; tacit technical knowledge includes individual invisible technical knowledge, such as judgment and intuition, and organizational invisible technical knowledge. The acquisition of explicit technical knowledge and tacit technical knowledge is crucial to enterprise technology innovation and can cause a new round of technical knowledge flow within the enterprise.

The generation and acquisition of technical knowledge in the process of enterprise technology innovation is the starting point of technical knowledge flow, which provides intellectual support for enterprise technology innovation activities. The process of acquiring external tacit technical knowledge and explicit technical knowledge in the

process of enterprise technology innovation is the process of inputting external technical knowledge about new products and new processes into the enterprise, and the input technical knowledge is objective. Therefore, the acquisition of technical knowledge in the process of technological innovation of enterprises is not generated, but relies on the internal absorption ability of enterprises to transform external technical knowledge into internal technical knowledge of enterprises under the joint action of various external factors, which is a conditional transformation process. Therefore, the generation and acquisition of technological knowledge have different impacts on enterprise technological innovation, which are manifested in the following two aspects.

Impact on the Cycle of Enterprise Technology Innovation

Technological innovation derived from the acquisition of technical knowledge from the open source community shortens the cycle of enterprise technological innovation because a large amount of R&D time is eliminated in the R&D phase of enterprise technological innovation. Relying on external acquisition to drive technological innovation is a shortcut. By acquiring external knowledge of new technologies in a paid or unpaid way, it saves the time of the enterprise in the process of research and development, reduces the risk of the enterprise in the process of research and development of new products and processes, improves the success rate of the enterprise's technological innovation, and helps the enterprise to produce marketable goods in accordance with the needs of the times. Therefore, promoting enterprise technological innovation activities by acquiring external knowledge of new technologies is conducive to shortening the enterprise technological innovation cycle.

Impact on Technology Innovation Mode

Although relying on the acquisition of external technological knowledge to promote enterprise technological innovation activities can shorten the enterprise technological innovation cycle, it is impossible to promote enterprises to master the most advanced technological knowledge due to the stickiness of the new technological knowledge obtained from external sources. The technical knowledge obtained by enterprises from outside in the process of technological innovation has a certain background dependence, and can only function effectively in a specific market atmosphere and working environment, and it is difficult to transfer the core technical know-how, technical secrets and other hidden technical knowledge with strong personal attachment in the process of technical knowledge input, which often causes enterprises to obtain external technical knowledge in the process of acquiring external technical knowledge, and cannot fully obtain all the New technical knowledge. In addition, the technical knowledge obtained from the outside is not the most advanced technical knowledge at that time, therefore, the technological innovation activities of enterprises can only be imitated and followed by innovation, and sometimes it may cause the failure of technological innovation of enterprises.

4 Conclusions

Innovation in open-source projects is achieved through active interaction between innovation actors, and knowledge flow explicitly considers these interactions. The subsequent research may focus on empirically testing the theory presented in this paper that a commercial firm's participation in an open-source community can affect a firm's technological innovation through knowledge flow, and thus affect patents. This impact on patents can be either in terms of the number of patent citations or patents, or in terms of the patent portfolio since only some of a firm's personnel participate in the open source community, it is likely to increase only the size of the patent portfolio related to the technology of the open source project.

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