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OPEN SOURCE: THE NEXT BIG THING IN TECHNOLOGY TRANSFER TO DEVELOPING NATIONS

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Abstract

Free Open Source (FOS) should be one of the least expensive and most effective solutions for technology and knowledge transfer to developing nations. This concept has diffused to several fields such as software, hardware, and content. FOS offers not only a low cost alternative for technology acquisition, but also for networking based on cooperation. In addition, the transaction costs of communication, licensing and negotiations are minimized, freeing up funds for real development. In this paper, FOS incentives, indicators, and measures are explained and the advantages of FOS as a viable technology and knowledge transfer tool for developing countries are highlighted.

Keywords: Free Open Source, Technology Transfer, Developing Nations, Modeling

I - Introduction

Most developing countries face similar problems regarding technology transfer. They include the lack of technical and know-how knowledge, Brain drain and the lack of appropriate technologies for their needs. The situation worsens with the absence of investment in technology and clear plans for technology adoption. The Free Open Source (FOS) concept is one of the cheapest yet most effective solutions for technology transfer, and is particularly useful in software programs. Typically, FOS is linked to software that is available online free of charge, including the source code or all the information needed for using and modifying the program. The FOS concept offers not only low cost to technology acquisition, but also an efficient scheme of cooperation to exploit

such technology. The nature of the cooperation to develop open source technologies and to customize such technologies can aid developing countries in the improvement of their current technology transfer systems.

II – Problems and Status of Technology Transfer in Developing Nations

For technology projects, developing countries rely mainly on the direct import of technology through the purchase of equipment, the implementation of turnkey projects and foreign direct investment (FDI). Certainly, there aspects are crucial for the rapid adoption of technologies that produce direct results in quality and performance. However, these spontaneous results are seldom combined with the transfer of knowledge and know-how to develop the technology that can lead to independent machinery purchasing, and the customization of the technology for the local needs.

Such problems of technology transfer to developing countries are categorized into four classes.

- Asymmetric Information: The knowledge holder does not reveal the information without incentives and the knowledge receptors cannot identify the value of the information before buying it. This is a well-known dilemma in technology transfer.

- Market Power: The technology owners are usually interested in covering the cost of the invention process and generate some profit, which increases the cost for the technology receptors.

- Free Movement of People - The free movement of people within a country or internationally between institutes, or in the establishment of new firms (at national or international levels) means the movement of knowledge and expertise. In developing countries, the regulations and policies do not usually support a suitable environment for free movement, attract expatriates to diffuse their knowledge, nor draw in investors from abroad to invest in activities that support knowledge accumulation.

- Intellectual property rights can prevent the adoption of technology because of licensing and royalty fees. Moreover, building on protected IPs can be costly and might even be prevented by the IP owner.

As reported in the literature within the frame of developing countries, the dominant technology transfer approaches are based on

- direct technology acquisition
- foreign direct investment
- advanced approaches such as the establishment of incubators and technology parks.

The first two approaches require high investments with limited real knowledge and know-how transfer, whereas the last requires high capital investment and proper strategies, policies, and

management to be in place. Moreover, globalization dictates that users have a more active role in the complexity and systemic character of new technologies. Users should not only be passive recipients or adapters, but active innovators. Without their involvement, the implementation of technology becomes too costly or even impossible. In the innovation process, users are a source of not only demand but also technical change.

This paper describes how the concepts of FOS can mitigate technology transfer problems in developing countries, enhance the quality of hardware and content knowledge transfer, and minimize the associated costs. The paper commences by stating the primary issues of technology transfer in developing countries. This is followed by an introduction to FOS incentives, indicators and measures, and the advantages of FOS as a viable technology transfer tool for developing countries. FOS is investigated by examining relevant literature and drawing conclusions.

III - Free Open Source Concepts

The us of Free and Open Source Software (FOSS) has become an international phenomenon, moving from relative obscurity to being the latest buzzword (Wong et al., 2004). The term, FOS, refers to software that is available without cost on the Internet and is developed in voluntarily basis. In order for software to be considered as FOSS, it must comply with the following conditions according to the Open Source Initiative OSI (Perens, 2006) and the Free Software Foundation (FSF):

- The source code must be freely available
- Free to use for any purpose
- Free to modify and to customize
- Free to redistribute
- Free to create derivative work
- Free to join the development and cooperation

FOS concepts and other products are characterized by their low cost (or even free), voluntary work, and continuously tested by many participants (including users). Besides that, the developers participate according to own needs, which increase the productivity and quality (Potdar et al., 2004). Moreover, FOS software is considered as a public good (created and used by the public). Indeed, the FOS achieved its goals in the software field in 2005, and is becoming more appropriate for other fields (Raymond, 2001).

FOS content is defined as “any kind of functional work, artwork, or other creative content having no legal restriction relative to people’s freedom to use, redistribute, improve, and share the content” (Wikipedia, 2006b). The best known example of these free contents is Wikipedia (http://www.wikipedia.org) the Web-based free-content encyclopedia project which allows visitors to edit its contents that have been written collaboratively by volunteers. In addition, both the Massachusetts Institute of Technology (MIT) OpenCourseWare project http://ocw.mit.edu/ and Harvard University Library Open Collections program http://ocp.hul.harvard.edu/ have

published courses and study materials on-line for free. There are also several attempts to define FOS Hardware, based on similar characteristics of FOS software and contents, where the designs, documentations, manuals, and software should be made available for free with no restriction on the use, distribution, implementation and development (Khatib et al., 2004; Lamberts, 2006; Seaman, 2006; Benjegerdes, 2006).

Currently, the FOS concept has penetrated countries such as India and Brazil, who are considered pioneers among the developing countries that have included the FOS in their IT policies, and established programs to support the use and development of FOSS.

IV - Technology Transfer and FOS

> *A substantial part of technology transfer occurs outside the technology transfer market itself. That is technical knowledge spreads internationally by noncommercial forms means, and it may even be transmitted free of charge.* (UNIDO, 1996)

Technology transfer refers not only to the movement of technology from the owner or producer to the receptor, but also refers to the diffusion of technology and knowledge through human activities (Zhao et al., 1992). Rogers (2003) has argued that technology transfer is not a one-way information flow, but a two-way communication process, based on information exchange between the producers and the receptors. Moreover, from the industry point of view, Dalziel (1994) indicated that the least effective technology transfer approaches are university research chairs, licensing, seminars, and workshops, whereas the most effective tools are collaborative and contract research, consulting, industry visits to universities, and student participation in work teams in the industry.

The FOS transfer model can be characterized by direct communication between the technology developers and users, common interests of members who are free to come and go, and the free access to information. The FOS development through cooperation among the developers, allows direct interaction with knowledge holders without bureaucracy barriers or legal restrictions which in turn, speeds up knowledge acquisition. Furthermore, the quality of the transferred knowledge will improve the communication channel is not affected by noise caused from legal issues.

The FOS development model is based on information, comments, test results, features, and requests exchanged between the developers and users. Moreover, the participants in the FOS are motivated by the exchange of knowledge to achieve recognition from their peers. Also, the technology transfer improves when the flow of information is two-way among the producers and consumers, which can be achieved through the FOS model adoption.

V - FOS vs. Other Technology Transfer models

The performance of the FOS technology transfer is far superior to that of other forms of technology transfer. For example, the transaction costs of negotiation and licensing in FDI and joint ventures are higher than those of FOS, since the technology is open to every one to join and leave with the developments and uses. Moreover, the cost of knowledge acquisition by FOS is almost nil, even if the know-how transfer is restricted or banned by joint ventures, licensing, or FDI. This is due to two facts: for the FOS concept, the knowledge is free to everyone without legal restriction, and the communication is free between the knowledge holders and users. It is also indicated that FOS's direct access to a knowledge source is more conductive to technology progress rather than acquiring research results through licensing (Dalziel, 1994).

Moreover, the adoption of other technology transfer concepts is complex and costly, whereas FOS requires stimulation and motivation only within the community. The risk of both the FOS technology transfer model and resultant technology is low since it does not require high investment and are driven by users' demand. The principle risk is the abandonment of projects by the developers such that no continuous support is provided. This issue should be expunged by industry embracing FOS as a legitimate tool.

Traditionally, technology developers and researchers are conflicted between publishing the results of their research and patenting their inventions, delaying the publication. This problem results from a mismatch of recognition and protection. In FOS, this is not the case, since all the participants are free to join and leave. The publication itself provides protection for the developers. They do not need to wait for patenting their research results.

On the other hand, the lack of investment in the FOS fields can be considered one of the major weaknesses in the adoption of FOS in technology transfer. Usually, FOS is developed by volunteers. It does not attract investors and funding institutes due to the lack of official commitment from the participants in FOS projects. Moreover the FOS concept is new, unconventional and highly dependent on the culture of the participants. All that must be considered is that the developers and users are aware of the advantages of FOS. Figure 1 provides a comparison between the major technology transfer mechanisms: FDI, joint ventures, and licensing, and FOS. Figure 1 depicts that FOS is superior to other mechanisms.

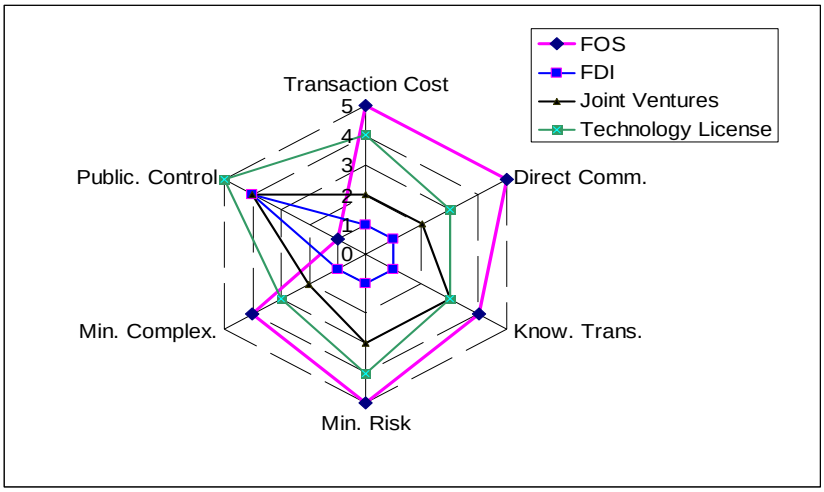

Figure 1: Comparison of technology transfer mechanisms

V - Free Open Source Incentives

The motivation structure is the most discussed topic in FOS literature. Some have divided the incentives into social (intrinsic) and economic (extrinsic), whereas other reports have divided the incentives into social, economic and technology ones. In this paper, the first classification is used for simplicity. Here, the intrinsic incentives are social factors, and the extrinsic incentives are economic factors.

Social Factors (Intrinsic)

The social factors (intrinsic) can be explained by the third level of Maslow's hierarchy of needs: belonging and love. Community identification, self satisfaction, and fulfillment that arise from writing programs are considered as the motivators of FOS developers, since their desire is to fulfill their personal needs, which was the case in both the PERL and Apache projects (Hars et al., 2001).

Internal motivation factors are summarized as follows:

- Knowledge sharing
- Satisfaction of achieving something valuable
- Professional reputation and recognition among peers
- Learning and improving personal skills
- Group problem solving
- Challenge proprietary software
- Sense of belonging to the community
- Enjoyment of developing projects

External factors from the FOSS survey shows that the major reasons of developers' participation

in FOS software development are:

• Learning and developing new skills
• Sharing knowledge
• Improving products
• Freedom in developing software

It is noteworthy that the literature shows that knowledge sharing among participants is a key motivator that can be used in technology transfer.

Economic Factors (Extrinsic)

Although the low price of FOS products is the primary factor for using these products, this section introduces other economic perspectives, not only in using FOS but also in developing products. (Dravis, 2003) has identified four economic incentives for the adoption of FOS software and support its development by governments

- Control the costs of software licensing and upgrades
- Control and increase the access to intellectual properties
- Reduce the reliance on proprietary software
- Promote software use in the public sectors

Although most of the developers (46%) do not earn money from FOS developments, developers do anticipate direct or indirect monetary rewards. Direct rewards for individuals are identified as the revenues from related products and services such as commercial consulting, training, distribution, support and implementation services, or rewards from current or future employers to seek higher wages or attractive job positions or career benefits.

Incentives for Using FOS

Although low cost is the most obvious factor for the adoption of FOS products, the transaction costs of licensing and acquisitions negotiation can be reduced. This stems from the fact that the information is available and licensing is simple. Some of the reasons that support the use of FOS products in firms follow

• To attain direct involvement in defining a software's features or adding them to increase the product's usability
• To acquire direct technical support from the developers
• To reduce that training and deployment costs by accessing on-line forums, mailing lists, and documentation

Incentives for Developing FOS Products

Lower R&D costs and skilled employees in the project field are considered in the literature as

major incentives for supporting FOS development. The reasons why companies develop FOS projects include the following

• to establish new communication channels with developers and customers
• to improve products due to direct customer feedback and extensive debugging and testing
• to develop skills through the cooperation within the community
• to access extra further resources and skilled developers
• to support the community in product development and customer support
• to minimize the time-to-market by early and continuous releases

Business Models of FOS

> *Collections of free software sold on CD-ROMs are important for the community, and selling them is an important way to raise funds for free software development* (Stallman, 2001).

IBM, the top patent holder in the US, encouraged the open source community to use 500 patents of its own in 2005. This allows IBM to introduce and expand their technologies in ways that the company might never do on its own. This is one of many examples of commercial and industrial interest in FOS. Firms can be involved in FOS models by direct development, supportive development, or new developments from FOS products.

Packaging and distributing software is also the most adopted business model (such as Linux distribution companies) and the most discussed in the literature (Ghosh et al., 2002). A second business model represents services around FOS products such as support, consulting, and training. Some other FOS business models include the following.

• software or drivers to sell hardware
• accessory items such as books and manuals, or other physical items
• applications, or derivative or customized products to meet specific needs

Also, it should be pointed out that when information becomes available for everyone in the community, entrepreneurs have more opportunities to use the information and develop new products and services that cost less by accessing information but also expertise beyond their fields or local community. In addition, the diffusion of the FOS concepts will increase the number of adopters of the technology and enable the industry to get feedback to improve their products.

According to Scotchmer (2004), scientists are motivated by publishing scientific results quickly without the registration of intellectual property rights. FOS models provide researchers with the flexibility publishing results, reserving their rights. Within the frame of open science where ideas are shared, researchers can build each other’s ideas, increasing the aggregate research progress. The researchers share the ideas not only within their community but also with the industry and end users, and achieve a wider range of ideas and comments that will accelerate their progress.

VI – Free Open Source as a Technology Transfer Mechanism for Developing Nations

The adoption of FOS concepts in developing countries promotes local research and development, rather than external suppliers or importing technological products. Also, FOS can provide the leverage for locally developed skills, increase local talents participation, minimize investment risks, and increase cost saving.

The cost advantages concern three areas

- low adoption costs since there is no need for expensive infrastructure, only communication channels
- low technology acquisition costs due to no license, import fees, or transaction overhead
- low technology development costs since the projects are developed in cooperation with participants, hence the divided cost.

Frequently, intellectual property rights inhibit developing countries from receiving technologies to develop similar technologies or new products, based on existing ones. However, FOS technologies have no such transfer or development problems.

The asymmetric information dilemma, discussed earlier, can be minimized by FOS, since the information is available so technology producers are recognized for their work and the receptor can evaluate the information. Moreover, developing countries will be in direct contact with global knowledge holders without any legal or political restrictions. This kind of interaction and project development will enable the development of local skills needed in the developing countries especially for the knowledge based industries.

The brain drain and free movement of skilled people problems in developing countries can be minimized, since FOS participants cooperate remotely. The knowledge is distributed in the host country and participants will have the freedom of movement. When developing countries import or license technologies, they do not have any control on the appropriateness for local needs. The FOS allows technology users to customize it according to their needs. Now, users can play active roles in technology transfer and open new sources of innovation.

The wide use of FOS increases the utility of the technology with the increase in the network size. This concept is known as the *network effect* where users provide feedback and standardize the use of the technology which in turn is evident for the usefulness of the technology (Scotchmer, 2004). From the industry and business point of view, FOS is a boost in the establishment of startup firms, offering new business models for existing products. Such activities mean support or maintenance contracts, alliances to establish standards, or different licenses for customized models of FOS technologies.

In developing countries, not only is the technology development weak, but also the technology development and adoption planning. Within the FOS community, plans can be derived by the developers themselves without political or external intervention or support. Governments have

only to define policies and plans to support the introduction of FOS concepts to the academic and research institutes and the industry to sponsor the use and development of FOS products and show their advantages.

Finally, an advantage of FOS to developing countries is the FOS content is courseware that can improve knowledge accessibility and education. It would also improve the teaching and learning approaches, and curriculum through peer review which in turn lowers the cost of course development.

VII - Conclusions

The paper highlights that the links between industry and academia in developing nations are weak which negatively impact the entire innovation system. The FOS development process which is principally founded on direct communication, free knowledge sharing, and trust can offer feasible achievements in developing countries. These three factors, especially direct communication, can lead to effective technology transfer. FOS concepts provide a suitable mechanism for technology transfer for developing nations that is inexpensive and lacks capital. In addition, the transaction costs of communication, licensing, and negotiations is minimized such that funds can be reserved to real development. Governments must define policies and plans to support the introduction of FOS concepts to both the universities/research institutes and the industry. They can sponsor the use and development of FOS products and show their advantages.

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