

Research Article

Leveraging the Open Source Software Movement for Development of China's Software Industry

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Abstract

The software industries in developing countries face enormous challenges in order to grow amid fierce competition of imports from software manufacturers in developed countries. In this paper, using China as an example, we identify the issues that must be addressed for the software industry, as well as the special characteristics of software products that must be dealt with carefully. We propose promoting Open Source Software as a strategy the government should adopt to foster the software industry and we then recommend a course of actions.

Introduction

As rapidly as China's economy has been growing recently, the country's software industry has maintained an even more dramatic pace. According to China's Ministry of Information Industry (MII) and National Bureau of Statistics (NBS), the revenue of China's software industry in 2002 reached US\$13.3 billion, a 46.5% increase from 2001 and more than 40 times that of 10 years ago (MII & NBS, 2003). Yet, such development has been outpaced by the domestic market's demand for quality software—and the service that comes with it. China's software industry only meets a small portion of the domestic demand. So far, foreign software and system integration account for 95.3% of the software market in China.

At the same time, China's ever-important presence in the global economy, especially after its entry into the WTO, requires tighter IT integration with the rest of the world. On the one hand, multinational companies with operations in China need to integrate their operations seamlessly with geographically distributed branches. On the other hand, even local firms in China, in order to do business with companies overseas, must become part of the increasingly global supply chains in which IT integration is a prerequisite. Besides the surging demand in the domestic software market, the global market has been contributing to the growth of China's IT industry. The Internet and the World Wide Web have made it possible for software engineers to collaborate on a project from geographically distant locations, which in turn opens up China's IT labor pool to the rest of the world, especially developed countries. China's IT labor force, still relatively inexperienced, has attracted outsourcing projects from developed countries, thanks to its size and competitively low costs (Auchard, 2004; Hua, 2004). In balancing the positioning of China's software industry, Li & Gao (2003) indicate that China should focus on its domestic market as a starting point and develop a more comprehensive strategy for the long term.

However, despite the fast growth rate and diversified products and service portfolios, there are several problems in China's software industry, which might hinder further development. For example, massive software piracy is a problem in China (BSA 2002), and Chinese software companies lack the competence of foreign software giants (such as Microsoft) which dominate China's software market (Loyola, 2002).

Economic theory predicts that the public good nature of software products and monopoly power may lead to market failure (Kreps, 1990). Recognizing that China's software industry is still in its infancy, the Chinese government has taken an active role in fostering the software industry. Among the policies the government adopted, the most visible and talked about is the promotion of Open Source Software (OSS).

OSS refers to software programs that are distributed with its source code, often under a license that sets conditions for modification, reuse, and redistribution. Many countries, such as Singapore, Germany, and Brazil, confer preferential treatment for development and use of OSS (Hahn, 2002). For example, Singapore offers tax breaks to companies using OSS instead of proprietary alternatives, such as Microsoft products. Many more countries are proposing support for OSS (Berger, 2002).

In this paper, we consider why and how OSS should be promoted as an answer to the issues facing China's software industry. We believe our analysis is not only applicable to China, but also sheds light on similar issues faced by other developing countries. Specifically, we aim to answer the following questions:

1. What are the critical issues facing China's software industry?
2. Should the governments of developing countries promote OSS to grow their software industry? Why?
3. If the answer to the prior question is yes, what strategy should the governments—in particular, China—employ to promote OSS?

The organization of the paper is as follows. We first briefly introduce the current status of OSS and review relevant literature. Then, we present an over-

view of China's software industry and the OSS movement to answer the first question. The next section addresses the second question by analyzing the economics of the software market and rationales for developing-country governments' promotion of OSS. Our main results are presented in the last section, where we argue the government should take an active, yet very careful, role in promoting OSS.

Current Status of OSS and the Research Literature

There are two types of OSS: non-copylefted and copylefted (Lerner & Tirole, 2002). Non-copylefted OSS not only opens its source, it also allows modification and redistribution, which can be free or for-profit. Programs such as FreeBSD or Apache fall into this category. Copylefted OSS requires that the source code be used only on the condition that the derived program must be made available to the public under the same license (Mustonen, 2003). Apparently, it is more restrictive than the non-copylefted. The best-known copylefted OSS is General Public License (GPL) from the GNU project, supported by the Free Software Foundation (FSF).¹

While the term Open Source was first used in 1998,² the OSS movement has its roots in the software programming community of the 1950s and '60s. In the 1960s, commercial computer manufacturers, such as IBM and DEC, provided source code with the software, which was free and shipped together with their large-scale computers. Sharing among programmers was encouraged to improve the software (Working Group on Libre Software, 2000). At the same time, thanks to the relatively small size of the community, the close-knit culture of computer science labs in some universities contributed to the sharing of source code and active exchange of ideas. However, by the early 1980s, the unbundling of software and hardware resulted in software that was not free or sharable. Meanwhile, the community has grown tremendously in size and many programmers are hired away by commercial companies to develop proprietary systems (Bennahum, 1996). To promote code-sharing and free software, Richard Stallman started the GNU

1. <http://www.gnu.org>

2. <http://www.opensource.org>

Project and founded the Free Software Foundation in the 1980s. That movement was joined by researchers at the University of California, Berkeley, who developed the BSD system. In 1992, Linus Torvalds published his code for the Linux kernel in various Usenet groups and mailing lists for review. Many people contributed to making it a complete operating system, and it became part of the GNU Project. In the recent years, Linux has seen a rapid increase in its install-base, especially in the server market.

The comeback of OSS has often been attributed to its many advantages, which proprietary software does not offer. From the developer's perspective, OSS rides on, and flourishes in, the "geek" culture that is deeply rooted in the software community, in a way that corporation developers do not. Programmers like to showcase their best work and OSS provides the best opportunity for public contribution and the resulting recognition. In contrast, at commercial companies, their work is proprietary and cannot be appreciated in its original form. Moreover, OSS programmers are part of a giant community, which fosters collaboration and friendly competition, while programmers working on proprietary software can only turn to their colleagues in the same company for help.

From the customer's perspective, the cost of using OSS is much less expensive than commercial software. Better yet, on the service front, one does not have to rely on a single company for support. Instead, a user can turn to the entire OSS community for help, and many people are willing to lend a hand. For many customers, OSS also relieves them from the increasing lock-ins forced by big companies such as Microsoft—they no longer need to fear exploitation by such companies because they have no choice once committed to a specific software vendor.

As popular as OSS has become, there are issues, mostly economic, that must be addressed for its potential to be fully realized. First and foremost, how can altruism, which is the basis of the OSS movement, survive the ultimate economics test? Will people continue to develop it for free forever, when the beneficiary—the customers—can make money using the software? Lerner and Tirole (2002) take a labor economics approach to the issue and study programmers' career choices. They analyze programmers' incentives to work in the OSS domain as op-

posed to the commercial software field. They argue that working in the OSS domain offers a programmer a *signaling incentive*—by working in OSS a programmer can be better positioned to receive benefits in the future from the experience and exposure gained in the process; at the same time, there is great self-satisfaction through peer recognition.

Secondly, will OSS survive the fierce competition from large commercial companies such as Microsoft? As this paper is being written, Microsoft has slashed the price of its industrial database software, SQLServer, to \$49, one tenth of the original price (Galli, 2003). It could use tactics similar to those that defeated Netscape in the Web browser market and take on OSS programs one by one (Sebenius, 2002). To answer this question of survival, the loose, decentralized governance structure of OSS development needs to be studied.

Last but not least, if the government believes OSS can improve social welfare, what role should it assume? Should it favor OSS through a national policy? Or should it promote healthy competition between OSS and proprietary software and let the market do its job? If in equilibrium—where both OSS and proprietary software have their fair share of the market—what should equilibrium look like? In the book on OSS economics and the government's role, edited by Robert Hahn (2002), several scholars hold different views.

While the literature has covered many aspects of OSS, the attention so far has been focused on the software industry in developed countries. In this setting, the industry is treated as a closed system—demand and supply all come from within the country. The issue is, given that OSS is able to produce superior software (at least in some area), how to encourage the growth of OSS in such a closed system. Recently, OSS has received much interest from developing countries, for reasons we are going to discuss in detail later. However, the same analysis of OSS in developed countries cannot be directly applied to developing countries as the market there has more players. OSS must compete with commercial products not only from domestic software makers, but also and more importantly, from the likes of Microsoft products that come from abroad. To some extent, OSS is opening a unique window of opportunity for developing countries to play the catch-up game. Therefore, the similar OSS questions, under the new context of a developing economy, involve

more issues than before, thus calling for new analysis.

As noted earlier, although our paper uses China as a case study, the same analysis can be applied to other developing countries, as the software industry shares similar characteristics and issues worldwide.

Software Industry Development and the OSS Movement in China

The Chinese Government's Efforts to Promote Development of the ICT Industry

The software sector is a major segment of the information and communication technology (ICT) industry, and its contribution to the overall ICT industry is becoming more important. Having experienced development at a pace faster than the economy as a whole, the ICT industry has become the most dynamic sector of China's economy in recent years. The MII predicts that the average growth rate of China's ICT industry will exceed 20% in the next five years.³

The rapid development of China's ICT industry can be traced back to a large extent to the active role played by the government. Since the 1980s, the Chinese government has actively encouraged the ICT industry to evolve to a higher level. In China's tenth Five-Year Plan (2000–2005), the Chinese government listed development of the information industry as a key sector of investment. The government is committed to significantly increasing R&D funding for the information industry during the tenth Five-Year period, with a focus on 12 areas of strategically important technologies. According to the minister of Science and Technology, Xu Guanhua (China to focus, 2002):

The ministry will concentrate on super scale integrated circuits and computer software, information security systems, e-administration and e-finance, function gene chips and bio chips, electric automobiles, magnetic levitation trains, new medicines and modernization of production of traditional Chinese medicines, intensive processing of farm produce, dairy product manufacturing, food security, water conservation farming, water pollution control and the establishment of key technical standards.

On the other hand, the Chinese government has been subsidizing the ICT industry in the last two decades by increasing the expenditure in IT/IS projects for government information management, such as the construction of State Economic Information System (1986–1995), implementation of the Golden Bridge Project, the Golden Cards Project, and the Golden Customs Project.⁴ Recent government projects, such as the e-government project, have seen the largest expenditure on ICT investment. In 1998, government procurement was 3.1 billion RMB Yuan, accounting for a mere 0.04% of GDP, or 0.29% of total government expenditure. Since then, procurement activities have grown rapidly, reaching 101 billion RMB Yuan (roughly US\$12 billion) in 2002, amounting to 9.64% of GDP or 4.58% of government spending. Plans to increase government spending, including plans to promote e-government (through such efforts as the Government Online project) and the "informatization" of society more generally (through such programs as Enterprise Online and Family Online) open a number of opportunities for promoting software development through procurement and standard-setting for procurement (Suttmeier & Yao, 2004).

Among all the measures taken by the government for the promotion of China's ICT development, the most noticeable and controversial is the government's push for the development and adoption of indigenous ICT standards, such as TD-SCDMA in 3G mobile telecom services and the WLAN Authentication and Privacy Infrastructure standard for wireless services. The Standards Administration of China (SAC) has called attention to the need for ongoing research on, and enforcement of, China's own technical standards. It has set a high priority on the development of technical standards for the hi-tech industry in 2003, with special attention given to standards for e-government, information security, and other fields. Meanwhile, the Ministry of Science and Technology is supporting a research project on China's standardization strategy, focusing on environmental science, information technology, agriculture, and manufacturing, to be completed in 2004 (Suttmeier & Yao, 2004). In creating its own standards, China hopes not only to use them on technical products domestically, but also increase the use

3. http://www.cebit-asia.com/exhibitors/industry_e.asp?ChrLeft?9

4. <http://us.tom.com/english/147.htm>

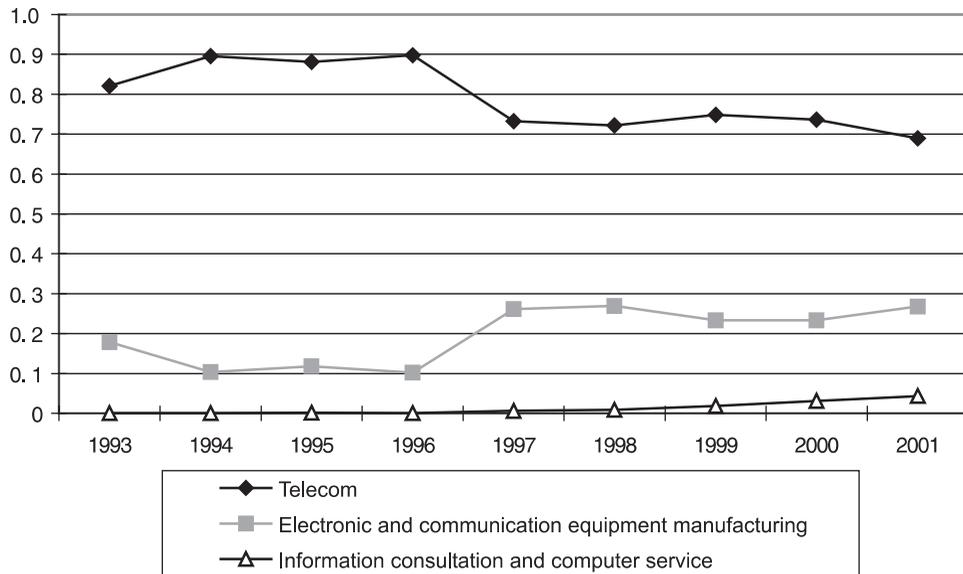


Figure 1. Shares of ICT Investment (1993–2001)

of Chinese innovations worldwide. Ramstad (2003) noted, “International companies that want access to that market are forced to make products that use them.” In a broader context, these efforts can be treated as a reflection of “neo-techno-nationalism: technological development in support of national economic and security interests is pursued through leveraging the opportunities presented by globalization for national advantage” (Yamada, 2000).

Current Status of China's Software Industry and Existing Problems

In the past 10 years China's software industry revenue has been growing at an annual rate of 20–40%, and in the last 3 years its software exports almost doubled every year (CSIA, 2004). However, it remains the weakest sector in China's ICT industry. From 1993 to 2001, the major part of China's ICT investment went to the telecommunications industry (Figure 1) with the information consultation and computer service industry (software industry included) receiving a very small proportion. The situation started to change around 2000, when investment in computer service was tripled in a single year, although it is much lower than those in the telecom and hardware sectors (Table 1).

Presently, China's software industry is capable of providing diversified software products, including platform software, middleware software, and appli-

cation software. The application software, including enterprise resource planning and accounting software, has the greatest share in the software market. Table 2 shows the relative shares of the three types of software in China's market. In 2002, China's application software accounted for 64.5% of the total domestic software products, and the Chinese government planned to grow the software industry to 259 billion RMB Yuan (US\$30 billion) in revenue, employing 800,000 software personnel. With the increasing domestic demand stimulated by its fast-growing economy and the demand from international outsourcing markets, it is projected that China will account for 3% of the world's software market (MII & NBS, 2003).

Although China's software industry has achieved a great success and shows a huge potential for the long run, there are still some major obstacles in the path of China's software industry development. The first obstacle is that the massive software piracy is not under control. The Business Software Alliance (BSA) (2003) estimates that pirated software accounts for 92% of the Chinese software market—the second highest piracy rate among the 86 countries the BSA tracks. The same study values the total market revenue lost due to piracy in China at US\$2.4 billion. While the amount of the loss may be over-estimated, considering most piracy copy buyers would not have spent much more to own an au-

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Table 1: The growth of software industry in China (1990–2001)

Year	The Total Revenue of Software Services (Billion RMB)	The Total Revenue of Software Products (Billion RMB)	Annual Growth Rate of Software Products (%)	Exports of Software (Billion RMB)
1990	—	0.22	—	—
1991	—	0.46	100	—
1992	2.3	1.98	335	—
1993	4.9	4.0	100.	—
1994	5.8	4.9	22.5	—
1995	7.7	6.8	38.8	—
1996	11.3	9.2	35.5	—
1997	14.8	11.2	21.7	—
1998	18.7	13.8	23.2	—
1999	23.8	17.6	27.5	2.1
2000	32.2	23.8	35.2	3.3
2001	40.6	33.0	38.7	6.0

Data Source: Compiled from the Bulletin of China Software Industry Association (2001), CCID (2001) and Computer World (2000)

Table 2: The structure of software products in China (1992–2001)

	The System Software		The Maintenance Software		The Application Software	
	Revenue Million US\$	Proportion	Revenue Million US\$	Proportion	Revenue Million US\$	Proportion
1992	1.95	8%	6.57	27%	15.57	65%
1993	4.38	9%	13.14	27%	31.14	64%
1994	5.47	9%	16.06	27%	38.08	64%
1995	7.91	10%	18.25	22%	56.57	68%
1996	10.34	9%	24.33	22%	77.25	67%
1997	16.67	12%	33.45	25%	86.13	63%
1998	21.17	13%	43.67	26%	103.04	61%
1999	25.55	12%	54.50	25%	134.06	63%
2000	40.39	14%	60.34	21%	188.56	65%
2001	60.83	15%	99.64	25%	241.00	60%

Source: Compiled from the Bulletin of China Software Industry Association (CSIA, 2001), CCID (<http://english.ccidnet.com/>), and MII & NBS (2003).

thetic program, it definitely hurts incentives for both foreign and domestic software firms to innovate and market their products in China. According to a survey conducted by *People's Daily* in 2001, more than a quarter of Chinese software firms believe software piracy is the most important barrier to their development, and about one fifth of the companies complain that software piracy has seriously

constrained further R&D investments into software products (Ju, 2001).

Recognizing the negative impact of piracy on the software market, the Chinese government has taken action against producers and sellers of pirated software. Many agree that it is an uphill battle. For example, piracy software is so prevalent that it has become a habit, even for consumers who can afford

legitimate copies, to purchase bootleg copies. How to effectively control software piracy is a major challenge to China.

Another problem is that the majority of Chinese software firms lack competence in the software market. This problem can be identified from two aspects:

1. No Chinese player is in the high end of the software market. China's domestic software industry is still at the primitive stage of development, and few Chinese software companies, if any, are capable of developing upper-level software, such as operating systems. As shown in Table 2, 85% of China's software products and services are in the categories of maintenance and application, and the market shares of system software are negligible. In 2002, application software accounted for 64.5% of the total revenue, implying the revenue from system software still contributes less to the overall revenue. In fact, the most valued market segments, such as operating systems and major packaged software, are dominated by foreign software superpowers.
2. The scales of Chinese software firms are generally too small. The size of software firms matters in the market because a firm's economic scale predetermines its ability to compete and to survive (In software, 2003). According to China's MII and NBS (2003), by 2002 China had 4,700 software companies, about double that of a year before. However, the sizes of China's software companies are still relatively small. In 2002, two-thirds of Chinese software companies had fewer than 50 employees. About 26% of the companies had between 50 and 300 employees. The revenues of 95.5% Chinese software companies were less than US\$12 million (100 million RMB Yuan) in 2002.

Furthermore, Chinese software companies lack senior professionals in core technology competencies. In 2002, of the 59,000 software personnel, 7% had Masters degrees, 33% had Bachelors degrees, and 17% had polytechnic degrees. There were only 157,000 R&D professionals scattered among 4,700 companies (MII & NBS, 2003).

As a matter of fact, by the end of 2002 the number of Chinese software companies certified by the Capability Maturity Model Integration Certification (CMM),⁵ an internationally-recognized standard of quality management for software firms, was only 2.5% among the total number in the world (China, European software institute, 2003). In the five levels of CMM standards, only a few Chinese firms have reached the middle level—CMM3 so far—and none have attained a higher level.

The low competency of Chinese software companies overall has become the bottleneck of China's software industry development. One of the direct outcomes is that it is hard for Chinese companies to compete effectively in the international outsourcing market, in which India software companies have won the majority of the contracts. In 2002 the revenue of China's software industry (US\$13.3 billion) was about the same level of that of India (US\$12 billion). However, China's revenue from software exports in 2002, at US\$1.5 billion, was far below that of India, at US\$9.5 billion (Offshore projects, 2003).

In the domestic software market, Chinese software companies are facing more pressures from powerful foreign competitors, which are typically more competitive and more experienced. The competition between Kingsoft and Microsoft Chinese-language word processing software is a classic case (Kingsoft Updates techniques, 2002). Kingsoft's Chinese word processing system had a market share of about 90% in 1994, but then it plummeted due to competition from the Microsoft Word system. With its advantages in operating systems, Microsoft launched its Windows XP that undermined Kingsoft's effort in its WPS word processing system. Finally, Kingsoft released WPS Office 2002, the latest version of its word processing system, to contend with its powerful U.S. archrival, Microsoft Office XP. Microsoft is now believed to have about 90% of the Chinese market for word processing software.

OSS Movement in China

Many governments around the world now use OSS as a key part of their strategic thrust in information technology. They have been motivated by the reduction in IT investments, in addition to the desire for independence, a drive for security and autonomy, and a means to address intellectual property rights

5. <http://www.sei.cmu.edu/>

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enforcement (Weevewavana & Weeratunga, 2004). The empowerment of the IT industry of a developing country through OSS development is an important opportunity, which has been identified by many researchers, and in particular, Steven Weber (2004). Such economies with a surplus of inexpensive technical manpower could combine the free software tools that the OS phenomenon provides to create an interesting comparative advantage both in local and global markets.

There is no doubt that the above-mentioned rationales for the promotion of OSS apply to the case of China. But it is important to put China's OSS movement into a broader context. Finding out the unique characteristics of China's OSS movement will not only have implications on the strategic choices of Chinese firms and governments, but also help foreign multinationals that have a stake in China's software markets.

As the largest developing country with an explosive domestic demand, the reason that China is trying to push the OSS movement has some unique rationales. Li & Gao (2003) discuss China's positioning strategy on the national level. They state that China should focus on its domestic market in the short run and with an eye to a more balanced development strategy in the future. Naturally, the OSS movement fits well into this positioning. The government's promotion of the OSS movement represents a special case of using the standards strategy, in connection with other policy tools, to enhance the competitive position of Chinese companies. As with other countries, China has been dissatisfied with its heavy dependence on Microsoft Windows as an operating system and on Microsoft applications software.

As shown in Table 3, in contrast with the grassroots nature of OSS in developed countries, the Chinese government has been playing a strong part in the whole process of advocating the OSS movement. Since the late 1990s, the Chinese software industry has been receiving significant government support. Policies to support the software industry have also been linked to the broader standards strategy, albeit with the added feature of using government procurement to reinforce the efforts to

establish standards. The effort in software standardization has focused on establishing Linux-based operating systems as an alternative to Windows and on developing domestic office automation products as alternatives to Microsoft Office and other imported application software.

In contrast with the closed-door nature of traditional China's software environment, the Chinese government and associations are strongly pushing for international collaboration between Chinese software players and their foreign counterparts. A Japan-China-Korea Open Source Software Promotion Partnership was established with the leading software industry associations of the three countries (the Japanese IT Service Industry Association, the Federation of Korean Information Industries, and the Chinese Software Association). The collaboration among the three nations has already borne fruit. China's leading Linux vendor, Red Flag Software Co., Ltd., and Japanese Linux vendor, Miracle Linux Cooperation, have co-developed Asianux, a Linux server operating system.⁶ The goal is to have a common-standard enterprise Linux platform for Enterprise systems in Asia that provides enterprise customers with high reliability, scalability, manageability, and better hardware and software compatibility. An Asianux certification partner program will invite more hardware and software products for certification. It will reduce development and certification costs, and provide Linux with high quality and low cost. Red Flag Software and Miracle will distribute and market Asianux without any modifications in each Linux distribution package in China and Japan. New products, such as Red Flag DC 4.1 and Miracle Linux V3.0, will be based on Asianux and each will be bundled with localized features in each country.⁷ Recently, a leading South Korean OSS developer, Haansoft joined the Asianux camp.⁸ Haansoft agreed to make the Linux operating system for server computers, dubbed Asianux, by August 2005 with Red Flag Software Co. of China and Miracle Linux Corp. of Japan.

The Yangfan and Qihang projects (both mean "to set sail"), promoted by the Beijing IT Industry Promotion Center, have attracted much attention from the public (Chinese office software, 2002). The

6. <http://www.asianux.com/>

7. http://www.asianux.com/about_us.php

8. <http://www.linuxinsider.com/story/37075.html>

Table 3: Milestones of the Chinese government's promotion of OSS

Time	Milestones
July 15, 1999	The Ministry of Information Industry held a forum on "Linux and China's software industry," which marked the first governmental initiative promoting Linux in China.
June 24, 2000	The State Council issued "Policies of promoting the development of the software and integrated electronic circuits industries" (known as Document No. 18), which promises to create a benign policy environment in areas such as financing, taxation, technology, exports, income distribution, human resources, procurement, certification, IPR protection. Document No. 18 is an important milestone, the first industry-specific document to support development of the software industry.
November 28, 2002	The State Council issued "Action plan for the revitalization of China's software industry" (known as Document No. 47) drafted by nine ministries, led by the State Office of Informatization, which put forward "Encouraging software development sectors of all the industries to change their mechanisms of operation, and to orientate towards society needs, and specialization."
December 11–12, 2002	The Ministry of Information and the Ministry of Science and Technology jointly held a seminar on "Linux software and application promotion," which was believed to be the second push for Linux in China.
February 25–26, 2003	Conference on "Guiding line for the revitalization of the software industry" held jointly by nine ministries.
August 2003	The State Council ordered that all government ministries adopt domestically produced software during the next cycle of software updates. The goal was to raise the percentage of government employees using domestically produced software from 30% to 100%.
June 29–30, 2004	Directed by the State Office of Informatization and the MII, the MOST, the Development Institute of China's Electronic and Information Industry held "Open Source Software World China 2004" in Beijing.
September 2004	The Open System Subcommittee of the China Software Association was established.

Yangfan 1.0 desktop Linux system is targeted to satisfy the government demand and serves as the platform for domestic desktop Linux systems and multiplatform office systems. Eighteen companies and universities have joined the Yangfan program, and its first desktop operation system, Yangfan 1.0, has been gradually put into use in government departments. In January 2004, project Yangfan 2004 kicked off, addressing the core technology issues for desktop Linux. The Qihang project was to provide the Linux-based network office system, with 23 software developers and 200 engineers involved.

On the firm level, Red Flag has been the most-often cited name in China's OSS movement. According to data from International Data Corp., the sales of Red Flag Linux Operating Systems ranked number two in the world in 2002. Red Flag Software Co., Ltd. was co-founded by the Software Research Institute of the Chinese Academy of Sciences and New-

Margin Venture Capital in June 2000, and was funded by CCID Capital Inc. under the MII in March 2001. The company focuses on the development and promotion of Linux-based operating systems and applications. Its product lines include desktop, server, high-performance computing OS, security operating systems, and embedded systems. It also provides comprehensive IT solutions and professional technical support. Red Flag Linux has been funded by many government departments, including the State Development Planning Commission, the Electronic Development Fund of the MII, the Special Key Software Project Fund of the Ministry of Science and Technology, the Beijing Science and Technology Commission, and the Beijing Economic and Trade Commission. With strategic alliances with IBM, Intel, HP, Oracle, BEA, Lenovo, Founder, Langchao, Dawning, Tongfang, TCL, and others, it has built a comprehensive, nationwide customer service net-

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work, including over 100 training partners, the Red Flag Certified Engineer Program, sale channels, and independent software vendor partners, which guarantees efficient customer support services.⁹

The true benefits of promoting OSS will go well beyond the cost reduction and security issues, which are common not only to developing but also developed nations. The open nature of the OSS movement will stimulate China's software industry in many ways, such as more collaboration among firms, community building, enhancing project management skills, and intellectual property rights enforcement. As Suttmeier and Yao (2004) put it, "The appeal to new standards is thus an attempt to change some of the rules of the game without changing the game itself." If China wants to move beyond "workshop of the world" status, in keeping with its aspirations to become a leader in new knowledge-based industries, it will require policies that will facilitate leapfrogging into leading roles in emerging technologies. China can use the promise of its huge market as an asset in developing distinctive standards with an expectation that its standards policies will be taken seriously by international business organizations in ways that the policies of other countries might not be.

As we elaborate in more detail in the next section, there is a good rationale for a developing country to promote OSS, but the transition will be anything but smooth. Such appeals from the OSS society as "governments everywhere, especially those in developing economies, should mandate a preference for OSS in procurements that embraces target adoption rates of 100%" clearly violates the principle of *there is no such thing in this world as a free lunch*.¹⁰ While most users insist Linux is cheaper to operate, reports from researchers, such as Forrester Research Inc. and The Yankee Group, assert that the "total cost of ownership"—including upgrades, support, and insurance against potential intellectual-property suits targeting Linux—can be higher than for Windows. The city government of Paris, with 17,000 desktop PCs and hundreds of servers, recently pulled back from its massive project of retiring Microsoft Windows software from all its machines and converting them to the Linux operating system after the results of a feasibility study rec-

ommended it stay with Windows. For Paris, the stumbling block was the expense of having to re-write programs and train thousands of employees on new software. Heidenheim in Germany recently chose not to adopt Linux for similar reasons (Not so fast, 2004). For a developing country such as China, the huge installed base of proprietary software, which is partially the result of massive piracy, will pose significant challenges to the adoption of OSS. The lost productivity during the transition process has to be calculated and weighed against the benefits of adopting OSS on both the macro and micro levels.

The Economics of Software and Rationales for Developing Country Governments' Promotion of OSS

Economists believe that free competition will bring about the best results, but only under some very strict and often unrealistic assumptions: no firm has dominant market power, perfect and symmetric information, free entry and exit, no externality, etc. When these conditions do not hold, there are good reasons for the government to get involved. Some unique features of the software market, which might lead to market failure, warrant intervention of the government.

General Features of Software and the Software Market

The software industry, as well as the software market, have some unique economic characteristics that set it apart from other industries. Such properties need to be well understood if the government is to nourish its growth in a healthy way.

First, the software industry is experiencing huge economies of scale in that software development requires a significant investment, although the cost of producing each additional copy of the software will be almost zero (von Hippel & von Krogh, 2003). Hence, the firm can only recover the fixed investment if they can protect their intellectual property and can charge more than the marginal cost. In economic terms, the software industry has the tendency to become a natural monopoly. To prevent abuse by the dominant market power, the government will have to play the role of regulator. The Microsoft trial

9. <http://www.redflag-linux.com/legyhq.html>

10. http://www.technetra.com/writings/open_government/lig_2004_09_html

has been the most notorious case in this regard (Woroch, Warren-Boulton, & Baseman, 1998; Economides, 2001).

Second, the network effects in the software industry make it appealing for the government to play the role of coordinator. Beginning with the paper by Katz and Shapiro (1985), a huge literature has emerged on the possibility of “market failure” in network industries. This literature revolves around the concept of “positive network externalities” (PNE). PNE stands for a situation in which—the telephone network being the archetypal case example—the benefit one consumer derives from using a product increases with the number of other consumers of the same product. The PNE concept has been extended to capture so-called indirect network externalities, which are said to exist in systems markets (where different products form elements of a system useful only in their entirety; e.g., the software and hardware systems) (Economides, 2001).

A large part of the literature is concerned with a phenomenon called “network tipping.” Network tipping means that in markets characterized by positive network externalities, one product tends to capture the whole market. Since this need not be due to some intrinsic superiority if positive network externalities are present, there exists the likelihood that inferior products, or rather, products that do not accurately reflect users’ requirements, dominate a market. Since this effect results from the uncoordinated behavior of users who each make their decisions without regard to the effects on other (potential) users thereby creating an externality, collective action might indeed prove the only way to increase responsiveness of technology supply markets to users’ needs. It is expected that the actions taken by the government can coordinate the interest of the market players to achieve the socially optimal result.

Last, related to the network effects in the software industry is the vertical externality in the computer market (Economides, 1999). Figure 2 shows a model for the computer market structure. The whole computer market consists of the computer system market and software market, and the software market segment can be further deconstructed into upstream and downstream segments. We can see that the computer system market and the software market overlap in the upstream software market: the operating systems.

Positive vertical externalities exist between pairs of annexed markets: computer hardware and operating systems; operating systems and application software; operating systems and tool software; tool software and application systems. Externalities may stand for complementarity. For example, a good operating system will strengthen the power of computer hardware; good hardware allows an operating system to fully exploit all its functions. It also represents inter-dependency. For example, the applications can only run in a compatible operating system; and the more applications available to an operating system, the more popular the operating system becomes.

If a software firm operates in both the upstream and the downstream segments, the vertical externalities between upstream software and downstream software (i.e., operating systems vs. application software) give the firm advantages in the downstream software market competition. The power of upstream software comes from network externalities due to its large user population. By improving the complementarities and interoperability of its downstream software, the market power of the software provider in the upstream segment can be further reinforced. Therefore, even if there is no charge for the downstream application software products, the software provider makes more aggregate profits by dominating the upstream software market (Economides, 1999).

Because of its closed-source nature, Microsoft’s control of the upstream Windows operating systems easily integrates its downstream application software to make the latter more competitive. The Web browser war in 1996 involving Microsoft, Netscape, and AOL is a well-known case in which Microsoft took the advantage of vertical integration between its Windows and Internet Explorer and won the competition (Sebenius, 2002). The above-mentioned case of Kingsoft’s loss to MS Office in China is another example of how Microsoft leverages its market power in the upstream segment and wins the Chinese word processor competition in the downstream segment.

Rationales for Developing Country Governments’ Promotion of OSS

One of the strong arguments for government intervention in the software market is that Open Source Software has the properties of a public good

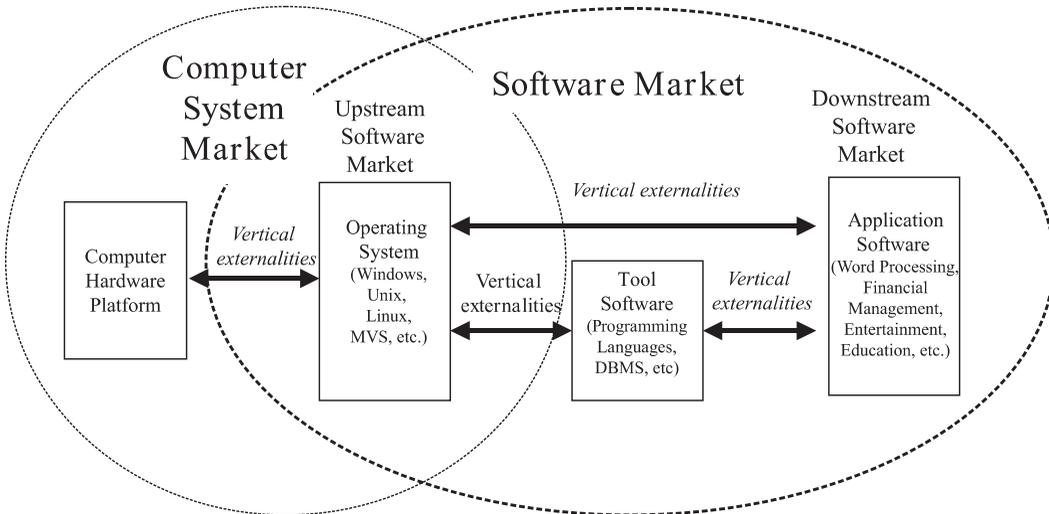


Figure 2. Software market structure

(von Hippel & von Krogh, 2003). The non-excludable nature of OSS implies that there is not enough incentive for users to contribute to the supply of the public good. There must be a mechanism to solve the “free rider problem.” In another aspect, OSS is a special public good that it is free of the most challenging issue: provision. Rather than the free rider problem of a typical public good, OSS has many enthusiastic free contributors. According to Lessig (2002), the OSS movements are completely consistent with a tradition of innovation and development outside the context of software. They may seem unique within the software industry, but they are not unique against the backdrop of development or innovation.

Support from the government can help overcome two primary market failures in the software market.

1. With its free program and source code, OSS is a piracy-free alternative to proprietary software. OSS programmers do not write software for profit, thus piracy is no longer an issue. Furthermore, the existence of quality OSS poses enormous pressure for proprietary software makers to lower the price for their products in order to compete. As previously mentioned, Microsoft was forced to slash the price of its database program to one-tenth of the previous level due to competition from OSS. Lower software prices will encourage purchase of legitimate programs and lower de-

mand for pirated copies. This, in turn, will increase overall social welfare as more people benefit from the program.

2. The adoption of OSS in upstream software markets will change the competitive landscape of the whole software industry. In the Linux vs. Windows case, the competition between an application based on Linux and a similar product by Microsoft is, in fact, the extension of that of Linux vs. Windows in the upstream software market. By breaking the dominance of Microsoft in the upstream OS segment, the vertical externalities between Linux and the Linux-based applications will mutually reinforce each other and finally change the equilibrium of the competition in the software market.

There are concerns on whether the government’s support of OSS makes economic sense when costs and benefits are carefully calculated. In the case of government support for public education, it benefits specific residents or citizens within a country or geographical area, and residents either pay tax or receive education benefits as a return. But when the beneficiary of supporting OSS R&D is everyone in the world, what are the incentives for the governments to support it? The roles of government in different stages of an industry’s development are different. In the developed world, the government must prevent the abuse of market power; the split of AT&T and the long-lasting Microsoft cases are

good examples. But in a developing country such as China, the software industry is in its infancy and can hardly survive in the face of aggressive invasion of foreign superpowers. The worldwide OSS movement is opening a new window of opportunity for developing countries in that rich sources of software secrets are freely given to them. The government's support to a large extent will help a developing country assimilate the accumulated knowledge and expertise of advanced countries and will help narrow the gap in their industry development. Moreover, the spillover effects of the software products and services will definitely justify government support.

Governments of developed countries advocate the use of OSS mainly due to its cost and performance advantages. For example, the German Bundestag reportedly picked Linux for most of its servers and Windows for its desktops because a study it commissioned found that was the best solution (Evans, 2002). The impact of Open Source Software in less-developed countries can be even greater than in regions with well-established information technology sectors. Among the many reasons, the following can be cited: (1) easy access to software products; (2) cost-effective transfer of software technology; (3) direct access to software technology; and (4) possibilities of making developments in advanced technologies. To some extent, the OSS movement is providing a shortcut for the developing countries to catch up with the developed world in the software and high-tech industries (Working Group on Libre Software, 2000).

When it comes to the issue of governments' roles in the OSS movement, it is not easy to reach a consensus. In the previous section we discussed the rationale for government support of OSS. Still, there are strong voices against government support of OSS. David Evans (2002) makes the following arguments against government involvement in the OSS movement:

The software industry itself does not scream out for government intervention. It has worked extremely well, and the success of the American software industry is widely credited to the lack of government involvement. If open source software is indeed superior, information technology specialists in business and government will use open source. They do not need legislation or legislators to make that decision for them.

Open source software that is available free of charge has done well when it offers advantages over competing software made by for-profit companies. Thus, tilting the playing field toward open source is likely to result in use when it is not the best alternative. And unnecessary government involvement could throw sand in the wheels of one of the most important engines of the new economy. (p.35)

The laissez-faire viewpoint of Evans does not consider the characteristics of the software industry. Besides, the arguments are mainly from the viewpoint of developed nations. For a developing country, OSS provides a unique opportunity to catch up. The government's involvement in OSS ought to be integrated into its overall software development strategy on the national and industry levels. To take full advantage of the freely available OSS resources, the governments must make additional investments to overcome the factors that might lead to market failure in the software industry and OSS.

Schmidt and Schnitzer (2002) suggest that the government should restrict itself to subsidizing basic research on software technology at universities and other academic institutions, which is aimed at promoting scientific developments for new software products. They believe interfering with the market artificially by favoring a specific product or OSS may cause strong network effects, and hence, reduce the competitiveness of the market. However, we re-emphasize: this view might be more relevant to the situation in developed countries. To a developing country where the software industry is under siege by powerful foreign software corporations, the government must be more active in fostering the necessary environment.

As shown in the previous section, the ultimate weakness of China's software industry, and of other developing nations as well, lies in the upstream operating systems sector. It is no coincidence that the Chinese and the Indian governments have so much commonality in their stance toward OSS. Despite India's success in its software sector, its major problem lies in its reliance on the outsourcing projects from the western world, which is a natural consequence of its negligible strength in the upstream section of the software industry's value chain.

The Chinese Government's Strategy in Promoting OSS

While many governments have been promoting OSS, the Chinese government presents a unique case. Since 1978, China has undergone a profound reform, transforming itself from a planned economy to a market economy. In this process, although the government's role in the economy has changed from direct involvement (through outright ownership) to market leveraging, its interventions in some industries, now much more indirect, are still powerful and effective. This implies that the Chinese government has more means than those of other developing countries, such as Brazil or India, in setting the direction for the development of an industry. Take telecommunications as an example: foreign participation clearly helps make China's telecommunications market more competitive. However, to protect its domestic telecommunications industry, regulations state that foreign firms can take up to 50% ownership in valued-added services in 2 years after China's entry into the WTO, and 49% ownership in both mobile and fixed-line services in 5–6 years (Zhang & Peng, 2000). In the semiconductor industry, the Chinese government has directly invested large sums in subsidizing the industry since the 1960s. Rather than continuing its direct intervention, the government has now resorted to market mechanisms to encourage investment in the semiconductor industry (China's IC Industry, 2004). The recently resolved value-added tax dispute between China and the United States provides a glimpse into the policies the Chinese government is applying (Agreement Ends, 2004).

So far, the effect of the Chinese government's intervention in the OSS movement remains to be seen, but there is no doubt that it will play an active role in OSS development. On the positive side, there is evidence that the Chinese government is tightening the enforcement of intellectual property rights in software and encouraging software firms to apply for patent protection (China issues new statute, 2001; First Chinese extraction, 2002).

On the negative side, some scholars are concerned with the Chinese government's strong regulatory power over the Internet's commercialization (Hughes, 2002). How such policies will affect the evolution of OSS or the Open Source movement is still to be seen.

Among all the policy levers the government can utilize, we believe the following are critical for the success of OSS in China.

Subsidizing Investment on the Software Sector and the R&D Activity in OSS in Particular

To promote the development of OSS, the government must take more active measures. These include direct investment in the basic R&D and tax breaks for software firms engaging in OSS-related R&D programs.

Microsoft's monopoly power is hard to break because of its dominant market share and the network effect. So far, Chinese upstream software providers have limited ability to provide better products to compete with Microsoft. Since any investment in R&D from a company may also benefit its OSS competitor, the company has less incentive to invest, and this demands that the government intervene in R&D support and concentrate on upstream software. With the better platforms supported by upstream OSS software as a public good backed by the government, more investments will be attracted to the development of downstream application products and services.

Adopting Open Source Software in the Public Sector

More and more nations have shown their support for the adoption of OSS products and services in the public sector. For example, Hahn (2002) reported that France passed a parliamentary bill requiring government-related institutions to use only OSS; Italy has a bill that mandates a preference for OSS in all governmental offices. China is a centralized country and the government might play a more important role in the promotion of the software industry. Government procurement accounts for a significant market share in the sales revenue of the software industry in such massive projects as e-government. By promoting OSS in the upstream sector, the government is sending a clear signal that there will be a huge demand for complementary downstream software products and services, which will induce more private-sector investment.

The future scenarios for China will most likely be the coexistence of commercial software and OSS-based applications: OSS will be prosperous in the server businesses; on the desktop level, Microsoft

products will remain in the dominant position. Given the existing familiarity with Windows, ready availability of pirated copies, and some recognized performance advantages of Microsoft products over the Chinese alternatives, personal computer users, including those within government offices, will likely continue to use Microsoft products.

Fostering Institutions that Coordinate OSS Movement and Building an OSS Community

According to Porter (2003), institutions for collaborations will play a more important role in competitiveness: industry associations, professional associations, technology associations, nonprofit think tanks, etc. Considered another asset of the Indian software industry, the Indian National Association of Software and Service Companies (NASSCOM)¹¹ has played a critical role. Formed in 1988, NASSCOM's objective is to act as a catalyst for the growth of the global, competitive, software-driven IT industry in India. NASSCOM is a nonprofit organization with over 870 member companies that collectively contribute to more than 95% of the revenues of the Indian software industry. Its members include software, Internet, and e-commerce companies spanning private and public sectors, including homegrown companies and multinationals. In comparison, NASSCOM's counterpart in China, the China Software Industry Association (CSIA)¹² does not play an important role in China's software industry. Due to the long history of China's planned economy, the government has usually played a strong role in industry development; therefore, almost all the non-government organizations are loosely organized and lack the resources and expertise to facilitate the participating companies. By nature, the OSS movement needs more coordination than any other proprietary software development. The government, however, is not in a position to take up this leadership, which calls for domain knowledge and joint effort from the software companies themselves. The Chinese government needs to foster the development of institutions that can coordinate domestic OSS developers and dialogue with international peers.

China's OSS community should include Chinese

firms, academic institutions, and government agencies. In addition, it should serve as a platform to coordinate the efforts of foreign superpowers, such as IBM, Sun, and Oracle, in order to enhance the linkages of Chinese institutions and major foreign firms. The endorsement of the Asianux standards by HP Oracle and others show their interest to collaborate with Chinese players. In August 2004, the MII set up the national-level MII-HP Linux Software Research Lab jointly with Hewlett-Packard to provide technical support and promote the development of China-based Linux products, solutions, and applications. HP has committed to provide 200 million RMB Yuan of software, hardware, and related technical support and training.

The government's efforts at fostering the OSS community will help overcome weaknesses in China's software industry as discussed in the previous section. As summarized by Suttmeier and Yao (2004), "Strong traditions of localism at both provincial and sub-provincial levels, and indeed a tough individualism among Chinese, points to cultural traits supporting resistance to standardization, as do difficulties in realizing consistent local implementation of national interest in a variety of policy areas. A strengthening of a national standards philosophy, with strong central leadership, may thus be a part of a national policy response to address what some might take to be domestic weaknesses impeding the standardization imperatives of modernity" (p. 9).

Promoting Education and Training in OSS: Fostering the Alumni Effect

Software is a knowledge-intensive product. Introducing OSS curriculum into universities will create a huge number of computer software professionals proficient in OSS from a young age. Companies such as Microsoft and Apple have been giving or discounting their products to students for years for the same reason. OSS has an advantage over proprietary products because of its cooperative nature. The culture of openness and altruism embedded in the OSS movement will also shape the youth's work ethics and attitude. By injecting OSS into curricula, the government acts as a promoter to the already-popular amateur OSS development. After the

11. <http://www.nasscom.org>

12. <http://www.csia.org.cn/>

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students graduate and join the workforce, the alumni effect and network effect will make the trend to OSS irreversible.

In the long run, China's ability to leverage the worldwide OSS movement will hinge on her contribution to the outside world. It will be important for China to play a more important and active role in the world OSS movement as a contributor, rather than as a mere free rider, which will also help change the image of China as the world's largest piracy nation. In this process, there is no doubt that the government policy will play a critical role. "The participation of individual software developers in developing countries in the absence of an organizational framework would largely be a hit or miss effort, with much less potential to build brand value and the country's reputation in the global software industry" (Weevewavana & Weeratunga, 2004).

Summary and Conclusion

In this paper, we discuss how the OSS movement can be leveraged to stimulate growth of the software industry in developing countries, using China as a case study. We identify the most pressing issues faced by China's software companies: namely, massive software piracy and lack of competitiveness, especially in systems software due to their small sizes and lack of experience. To solve these problems, we need to understand the characteristics of the software market. Software products, in general, have the characteristics of public goods that feature huge economies of scale, network effects, as well as vertical externalities. The software market is also dominated by some giant players with huge market power. Microsoft, with its army of operating systems (Windows), application software offerings (Office, Internet Explorer), and a well-known history of eliminating small players in any field in which it wants to have a presence, is a perfect case in point. Once a monopoly is established, it is difficult for smaller, new entrants to compete. Even worse, the monopoly power can be extended to existing areas to drive out once-powerful competitors, as made obvious by the browser war between Internet Explorer and Netscape Navigator.

OSS, with its vast developer community and altruistic, cooperative nature, offers an alternative to proprietary software. We posit that it should be promoted as a strategy for developing countries to grow their software industry.

While researchers have shown great interest in the economics of OSS recently, their research has been primarily focused on developed countries. They study issues such as why the labor force would choose to work on OSS rather than proprietary software, and why OSS has survived and flourished despite brutal competition from commercial software makers. However, the problems faced by the software industry in developing countries are quite different as their competition comes not only from within the country but also from abroad. The latter, often at a much larger scale than the domestic counterparts, enjoys a great advantage with their seemingly bottomless financial resources. We argue that OSS will help China solve the piracy problem, as well as change the competitive landscape of the software industry. OSS, as a special public good, should receive government's support just like basic research and education.

In particular, we propose that the Chinese government take the following actions to promote OSS:

- Subsidize the software sector, especially the R&D efforts in OSS.
- Adopt OSS in the public sector.
- Foster industry institutions that coordinate collaboration in developing OSS products and build a strong OSS community.
- Promote OSS education and training.

These policies will not tip the playing field of OSS vs. commercial software; instead, they are meant to increase the awareness and competitiveness of OSS so the competition outcome, whether or not OSS wins, will improve the overall social welfare. ■

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