

Increasing Returns and the Diffusion of Linux in China

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Article:

China's unique combination of institutions, industries, and markets has fostered the generation and use of Linux-related innovations. Analyzing increasing returns provides key insight into this proliferation.

China has become a global economic and technological powerhouse. It is fast emerging as the main rival of the US and other industrialized countries in the technology industry and has the potential to set global standards in its fields of expertise. Among many examples that illustrate this trend, one is particularly telling: China's open source software (OSS) industry. The scale of OSS development and deployment in China is large enough to notice at the global level. Nearly all major global OSS players, including Hewlett-Packard, Intel, Sun, Oracle, and IBM, have significant operations in China and have collaborated with Chinese partners to get a share of this exponentially growing market.

Although many types of OSS are available, the system that deserves special attention from the China perspective is Linux, the flagship of OSS (A. Applewhite, "Should Governments Go Open Source?" *IEEE Software*, vol. 20, no. 4, 2003, pp. 88–91). In June 2004, China's Linux-based Dawning 4000A ranked 10th among the world's fastest supercomputers. And, in 2005, the country's Linux market grew by 27.1 percent (*Global News Wire - Asia Africa Intelligence Wire*, "Linux Expected to Soar in China," 21 April 2006). The Chinese IT research firm CCID Consulting predicted a compound annual growth rate of 49.3 percent from 2005 to 2009 for the country's Linux server software market. Likewise, International Data Corporation predicts the compound annual growth rate of China's Linux market for 2006 to 2010 to be 34 percent.

What factors are driving China's Linux industry? An increasing-returns approach to analyzing China's quick and massive development and diffusion of Linux can provide key insights. The law of increasing returns—*as opposed to diminishing returns*—argues that economies of scale, decreasing costs, and other feedback mechanisms lead to further success of a technology that is already successful in a market. W.B. Arthur notes:

"Increasing returns are the tendency for that which is ahead to get farther ahead, for that which loses advantage to lose further advantage. They are mechanisms of positive feedback that operate—within markets, businesses, and industries—to reinforce that which gains success or aggravate that which suffers loss" (W.B. Arthur, "Increasing Returns and the New World of Business," *Harvard Business Rev.*, vol. 74, no. 4, 1996, pp. 100–109). The increasing-returns approach helps explain how firms, innovations, industries, and the environment interact.

In this article, I explore evidence of the effects of increasing returns in China's Linux industry and analyze whether feedback provided by institutions, industry, and the market in China might allow Linux to gain an edge over proprietary software. In particular, I focus on three positive feedback systems for this evidence:

sociopolitical, cognitive, and economic (W.B. Arthur, "Positive Feedbacks in the Economy," *Scientific Am.*, Feb. 1990, pp. 92–99). Figure 1 depicts how each of these feedback systems influences Linux diffusion in China.

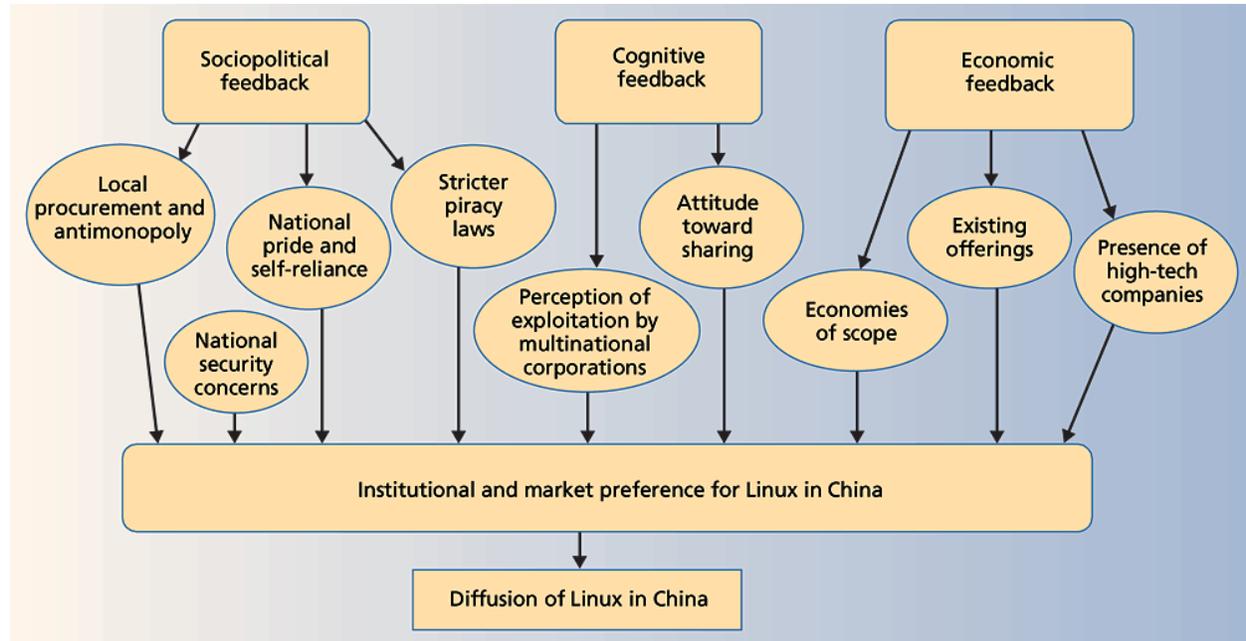


Figure 1. Understanding Linux diffusion in China.

Definitions

The first two types of feedback systems, sociopolitical and cognitive, relate to formal and informal institutions. Nobel laureate Douglass North defines institutions as "macro-level rules of the game" (D.C. North, *Institutions, Institutional Change and Economic Performance*, Cambridge Univ. Press, 1990). Institutions comprise three pillars: normative, regulative, and cognitive (W.R. Scott, *Institutions and Organizations*, Sage, 2001). Sociopolitical feedback systems capture the normative and regulative pillars. Social feedback closely relates to normative institutions and requires various players to take into account assumptions and value systems of cultures. Political feedback relates to regulative institutions and is applied in an organized way by formally appointed groups. Regulatory bodies, such as China's State Council and the World Trade Organization (WTO), and the existing laws influence the software industry and market to behave in certain ways.

Cognitive institutions, on the other hand, influence the lens through which software users view Linux and proprietary software. Behaviors related to cognitive institutions result from habits. Software developers and users thus may not be aware of their habitual compliance to cognitive rules.

The third type of feedback system, economic, is characteristic of industries and markets.

Sociopolitical Feedback Loops

Two common features of Chinese institutions related to social feedback that show a preference for Linux are national security concerns and the principles of self-reliance and national pride. Key elements of political feedback include local procurement law, stricter piracy laws, and antimonopoly and antitrust legislation, which was discussed in the standing committee of the National People's Congress in August 2007 and will be effective on 1 Aug. 2008 (A. Batson and J. Leow, "Beijing's Antitrust Plan Raises Questions" *Wall Street J.*, 30 Aug. 2007, p. A6).

National security concerns

A product of China's transition to capitalism was the evolution of the People's Liberation Army (PLA) as a major player in China's computing industry. In an editorial on "information colonialism" in February 2000, the

People's Liberation Army Daily wrote: "Without information security, there is no national security in politics, economics, and military affairs. While learning from others, China should not be under their control."

A June 2000 *China Economic Times* article discusses the views of Xu Guanhua, then China's vice minister of science and technology, on how high technology affects national security. Claiming that developed countries have used many high-tech arms in battle, Guanhua discussed the likelihood that technology-exporting countries might have installed software for "coercing, attacking, or sabotage" in products sold to China. The Chinese government went as far as to think that Microsoft and the US government spies on Chinese computers through secret back doors in Microsoft products (G.P. Goad and L. Holland, "China Joins Linux Bandwagon," *Far Eastern Econ. Rev.*, 24 Feb. 2000, pp. 8–12). Linux, however, has no undetectable vulnerabilities and thus is perceived as having a clear security advantage. Linux would protect the government against foreign hackers, according to a vice director of software research at the Chinese Academy of Sciences.

Principles of self-reliance and national pride

Since Mao Tse Tung's time, the principles of self-reliance and national pride have guided China's economic system. Though the negative attitude toward technology imports and foreign investment has changed, a high level of advocacy for national self-reliance and domestic technology development still exists among China's policy makers, researchers, scientists, and military leaders.

Using foreign software has been an ongoing concern in China. In the past, the country has made several attempts to develop an operating system, but it failed because of its inability to compete in proprietary software. Linux has acted as a leapfrogging technology that let China overcome this competitive disadvantage, and thus the country began Linux development in 1998. In August 1999, the Software Research Institute of the Chinese Academy of Science launched Red Flag Linux, a local, open source competitor to Windows. The system helped promote Linux in China, and today it is widely used in the country's government departments and agencies.

The Chinese government also established the Beijing Software Industry Production Center. Building on Red Flag and Cosix Linux and coordinating the efforts of a hundred engineers across 18 organizations, the center launched Yangfan Linux in 2002. Based on versions of Linux developed by Red Flag and China Computer Software, Yangfan was installed in 2,800 government computers in Beijing during the first six months of its launch. The center also developed office applications and other Linux-based software.

In 1999, Linux development was the only software project on a list of the government's top technology priorities. In 2004, Linux Internet server software and Linux mobile phone software were among the 19 projects identified by the Ministry of Information Industry for IT funds, which was founded by the State Council in 1986 to encourage R&D in IT. Today, China's scientists and engineers are working to create Chinese standards in computer operating systems and audio-video compression to 3G standards and Internet Protocol TV, aiming to reverse the flow of fees by exporting Chinese standards. By 2010, China hopes to capture 60 percent of the domestic software market and increase software exports tenfold. Not only would this increase self-reliance, but having a custom-made OS could reinforce national pride.

Local procurement and antimonopoly laws

The Government Procurement Law enacted in 2003 requires government departments to procure domestic goods and services. In 2002, even before such a law was enacted, six out of seven government software contracts went to Chinese vendors. Despite China's accession to the WTO, government procurement is excluded from the scope of multilateral trade rules governing the WTO. Thus, China is not obliged to open its government procurement to foreign firms. Some estimates suggest that the government accounts for 25 percent of China's software market. The local procurement requirement is thus giving a major boost to China's Linux industry. Moreover, citing Microsoft's dominance in the country's software market, a 2004 report of the Chinese State Administration for Industry and Commerce argued the urgent need for antimonopoly and antitrust laws.

Some analysts argue that the new antimonopoly law can benefit domestic and government-owned companies at the cost of foreign multinationals (A. Batson and J. Leow, "Beijing's Antitrust Plan Raises Questions," *Wall Street J.*, 30 Aug. 2007, p. A6).

Stricter piracy laws

According to the Business Software Alliance's Annual Global Software Piracy Study, 82 percent of the software used in China in 2006 was pirated. As a WTO member, China is required to adhere to the Agreement on Trade-Related Aspects of Intellectual Property Rights, which requires the country to provide adequate legal and enforcement tools to prevent piracy. For the first 10 years of its WTO membership, China is subject to an annual review of its WTO obligations, and many countries are likely to put pressure on China to act on intellectual property infringement. In 2002, China enacted piracy laws that stipulate that buyers of pirated goods can be fined 5 to 10 times the value of the goods, and manufacturers face jail time and equipment confiscation. Microsoft chief Bill Gates noted that the proportion of new PCs shipped with legitimate software crossed 40 percent by mid-2007 (D. Kirkpatrick, "How Microsoft Conquered China: Or Is It the Other Way," *Fortune*, 17 July 2007). Analysts, however, argue that OSS happens to be the legitimate software in most cases and suggest that the new rules could help fuel the growth of Linux (D. Lague, "Small Steps in a Long Fight Against Piracy; Chinese Measures Seen as Good Start," *The International Herald Tribune*, 18 May 2006, p. 19). It is important to note that an earlier attempt by the Chinese government to mandate a nationwide switch from Windows to Red Flag Linux failed. However, China's requirement to comply with Trips has made the relative value proposition of Linux stronger.

The Cognitive Feedback Loops

Cognitive feedback loops are associated with cognitive programs built on the mental maps of individuals (A.S. Huff, "Mapping Strategic Thought," *Mapping Strategic Thought*, A.S. Huff, ed., Wiley, 1990, pp. 11–49). Deep-rooted perceptions of exploitation by foreign multinationals combined with the Chinese attitude toward software sharing provide a cognitive preference for Linux in China.

Perception of exploitation by foreign multinationals

Although a large proportion of Chinese users do not pay the full retail price for software (D. Evans, "The Great (Trade) Wall of China," *Wall Street J.*, 28 June 2004, p. A10)—thanks mainly to widespread piracy—those who do pay can find Microsoft products' license fees expensive. The company recently dropped the price of its Vista operating system in China from US\$238 (or almost four months' salary for an average Chinese worker) to \$118 for the Home Premium package to combat piracy, according to *The Wall Street Journal*.

In 2000, a piracy lawsuit by Microsoft against a small local firm only reinforced the company's reputation as a foreign bully (B. Rabano and A. Shameen, "Brickbats for Bill: Microsoft's Public Image is Under Fire in Asia at a Time the Software Giant Needs All the Friends It Can Get," *Asiaweek*, 10 Nov. 2000, p. 1).

Attitude toward software sharing

A distinguishing feature of Linux is that unlike proprietary software, it can be shared legally. Throughout China's history, regard for the concept of intellectual property has been lacking. Confucianism, which has had a strong influence on Chinese politics and culture, emphasizes the importance of the family and society over the rights of the individual, a traditional Western value. This disparity explains the difference in the copyrights systems and attitudes toward piracy in China versus Western nations. However, the Chinese government has escalated its crackdown on piracy, which is likely to boost the diffusion of Linux.

The novelty of IT products in developing countries also contributes to China's attitude toward software sharing. When a computer is still an exotic product in many parts of China, it's difficult for people in those regions to appreciate the impact of software sharing. That said, software sharing in the US was more common when computers were found only in universities than it is today.

The Economic Feedback Loops

Economic feedback systems related to China's industries and markets also favor Linux diffusion.

Economies of scope

Economies of scope exist if increasing the variety of activities that Linux can perform can reduce costs. Red Flag's Linux applications are already used in China's aircraft, weapons systems, vehicles, industrial equipment, and consumer devices.

The mobile industry is among the many sizable sectors for increased Linux deployments. Given the size and growth of China's mobile market, Linux development for mobile devices will have a powerful global impact. China's mobile market is the biggest in the world (N. Kshetri, N.C. Williamson and D.L. Bourgon, "China: M-Commerce in World's Largest Mobile Market," N. Dholakia, M. Rask and R. Dholakia, eds., *M-Commerce in North America, Europe and Asia-Pacific: Country Perspectives*, Idea Group Publishing, 2006, pp. 34–45). Working together, Redflag, Eforce, Culturecom, and Mobile Telecom in 2002 introduced the Chinese 2000 Mobile Linux Operating System for handheld devices. Soon after, Beijing named it as the municipal government's official OS. Similarly, in mid-2003, Transmeta, the developer of Midori Linux, formed an alliance with China 2000 Holdings to develop a Linux OS for mobile devices in China. Moreover, in July 2004, Datang Telecom Technology, the IP owner of the Time Division-Synchronous Code Division Multiple Access standard, confirmed that it selected Linux as its 3G handset's OS. According to research firm Research and Markets, Linux will have 34 percent of the smartphone OS market in China by 2010.

Foreign multinationals in the cellular telecom sector are also designing Linux-based cell phones in China. By 2004, 10 percent of mobile handsets sold globally by Nokia were designed in the Nokia Product Development Centre in Beijing. In May 2005, Nokia announced its plan to expand R&D activities in China so that 40 percent of handsets produced by its mobile phone business division would be designed and developed in the country. Similarly, in 2000, a group of engineers at Motorola's Beijing R&D center started working on Linux-based cell phones. Since then, Linux has been an integral part of the company's software strategy. As of 2005, Motorola offered five Linux-based phones globally.

Existing offerings

Foreign software, especially Microsoft Windows, dominates China's computing market. Chinese versions of Windows, however, lack ease of use (for example, requiring many keystrokes to create a single Chinese character). Chinese consumers also believe that Microsoft's Chinese products are technically inferior to the English versions ("Microsoft in China: Clash of Titans," CNN.com, 23 Feb. 2000; <http://archives.cnn.com/2000/TECH/computing/02/23/microsoft.china.idg/>).

Also, the extensive computing needs of the PLA, a major player and consumer in China's computing market, outpaced existing resources. Exacerbating the situation, the US and its allies in the Coordinating Committee for Multilateral Export Security restricted high-tech exports to China (US law still restricts the sales of computers that exceed specified performance limits). Consequently, Linux deployment has been an alternative to conventional supercomputing for the PLA. The organization was among the earliest adopters of Linux and has been using Linux to do large-scale clustering by combining less-powerful computers to perform complex calculations. Over 100 servers are clustered in a typical single system.

Presence of high-tech companies

Users are typical innovators in OSS. Nevertheless, commercial companies find indirect ways to profit. The demands of some segments are boosted by the success of a complementary open source program, and the expertise of these companies in such segments boosts the demand for their offerings. For instance, IBM has benefited by bundling its DB2 Universal Database software, which provides e-business solutions for small-and medium-sized businesses, with Red Flag Linux (S. Shankland, "IBM in Bundling Deal with Red Flag Linux," 11 Sept. 2003, CNET News.com; <http://news.zdnet.co.uk/software/0,1000000121,39116263,00.htm>). Such strategies also entail encouraging and subsidizing the open source movement through such activities as

allocating a few programmers to an open source project. Oracle and Red Flag, for instance, have set up a joint escalation center to help solve problems that Red Flag's customers encounter. According to a July 2005 *Computerworld* report, several big banks announced their plans to switch from Unix to Linux thanks mainly to the latter's better performance and vendor supports.

Thanks to ever-increasing industrial-government partnerships and a highly motivated and well-trained engineering workforce, a large number of high-tech firms have made inroads into China. The number of companies involved in developing Linux, as well as providing software and services for Chinese Linux users, is increasing rapidly.

Researchers have identified three categories of motivations for multinationals to globalize their technological activities: international exploitation of technological capabilities by means of activities such as export, moving production activities abroad, and licensing; collaboration among public and business institutions; and generation of innovations across more than one country (D. Archibugi and J. Michie, "Technological Globalisation or National Systems of Innovation?" *Futures*, vol. 29, no. 2, 1997, pp. 121–137).

International exploitation of technological capabilities. Multinationals are providing products and services not generated by China's key players. In August 1999, in its Linux strategy in China, Motorola announced that it would provide Linux-based platforms and services of support, training, and systems integration. In April 2000, Motorola and TurboLinux announced plans to jointly develop a Chinese-language version of an embedded Linux OS running on the PowerPC 8240 microprocessor. Similarly, Motorola and Picsel Technologies have made Picsel Browser available on Motorola phones in China. Picsel Browser delivers the full Web and multidocument browsing on a Linux-based smartphone. In 2000, IBM reported plans to install Red Flag's Linux operating system in its S/390 computers, which are widely used in China's banking and securities networks (Archibugi and Michie, 1997). IBM also signed a marketing agreement with Red Flag to bundle IBM DB2 Express Database Software with Red Flag Linux. Likewise, in 2005, in an attempt to speed up the development and adoption of Linux-based applications, especially in developing markets such as China, IBM and Red Hat launched a joint worldwide initiative. The two company's roles in the initiative entails providing Linux developers with technical support and implementation expertise (C. Martens, "Big Blue, Red Hat Go Global on Linux," *Network World*, 26 Sept. 2005, vol. 22, no. 38, p. 31).

Collaboration among public and business institutions. Foreign high-tech companies are collaborating with public and business institutions in China. The Chinese Academy of Sciences, Chinese Software Institute launched Hongqi Linux (an all-Chinese OS) and its application solutions with Compaq in 1999; and Chinese Penguin64 with Singapore's Donovan Systems in 2000. Red Flag has collaborated with a number of foreign companies in a wide range of Linux-related projects. In 2005, South Korea's Haansoft, Japan's Miracle and China's Red Flag Software launched Asianux 2.0, a version of the open-source operating system for Asia (S. Lemon, "Asianux 2.0 launch Today," *CIO*, August 2005, <http://www.cio-asia.com/ShowPage.aspx?pagetype=2&articleid=2476&pubid=5&issueid=60>) Similarly, Motorola collaborated with Lineo, developer of embedded Linux, and Caldera, provider of Linux for commercial applications. IBM has an alliance with Kingsoft, China's biggest office-automation-software vendor, to develop desktop Linux applications. Likewise, according to an April 2005 report in *R&D* magazine, China's Sun Wah Linux and Japan's VA Linux Systems agreed to create a strategic technology alliance for telecom and enterprise systems markets.

Generation of Linux-related innovations in China. Multinationals are generating Linux-related innovations in China. Mainly because of the Chinese government's Linux-centric policies, Motorola's Beijing R&D team took initiatives to develop Linux-based phones. Linux has been an integral part of the company's software strategy. As of the mid-2005, Motorola offered five Linux-based phones globally. The A780 model, available in the U.S. and Europe, was developed in China, which lets users write on the screen with just a finger, rather than a stylus (K. Chen and J. Dean, "Low Costs, Plentiful Talent Make China a Global Magnet for R&D," *Wall Street J.*, 13

Mar. 2006, p. A1). Similarly, in October, 2003, Oracle opened China Development Center in Beijing, which concentrates on Linux and e-government solutions.

Conclusion

China's unique assimilation of capitalism and socialism has fostered Linux development in the country. Policies that are reminiscent of the Chinese Communist Public Goods Regime and the country's Confucianism heritage provide positive sociopolitical and cognitive feedback. The regulative factors (such as, piracy and local procurement laws), the normative factors (the shared social knowledge that people hold regarding and the importance of national security and a domestically developed operating system), and the cognitive factors (the beliefs, values, and social norms related to software sharing and a deep-rooted perception of exploitation by foreign multinationals) foster an institutional preference for Linux. Although some of these factors such as local procurement and antimonopoly laws, national security concerns, and the principle of self-reliance can apply to many countries, they uniquely affect China.

The edge that Linux provides is likely to result in the emergence of China-based firms as powerful rivals to the incumbents in the global software industry, especially in developing countries. These countries have been historically locked out of high-tech products because they lacked the wealth and skills necessary to purchase and use the products. Software demands in these markets typically are small and hence not attractive for large companies such as Microsoft, IBM, Oracle, and SAP. Linux, however, has some *disruptive* and *discontinuous* characteristics that are likely to make it attractive for developing countries. As with other disruptive innovations, which overturn the status quo, (C.M. Christensen, M.E. Raynor, and S.D. Anthony, "Six Keys to Building New Markets by Unleashing Disruptive Innovation," *Harvard Management Update*, 10 Mar. 2003; <http://hbswk.hbs.edu/item/3374.html>), the incumbents, such as software giants from industrialized countries, may lack ability to compete in the new game Linux has created. What's more, with the creation of new consumption and the improvement in innovation, Linux developers may also attract incumbents' customers.