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ABSTRACT

This paper examines factors at work when an established standard competes with an open-source offering. Although the argument is often framed along price or technical features, these aspects may describe only a portion of the consumer's adoption calculus. Modeling the consumer's technology platform adoption decision is critical to developing market preservation for incumbents and market invasion strategies by rivals. This paper proposes a theory grounded, quantitative model for technology adoption in the presence of network effects, switching costs, and software piracy. We apply the model as a strategy development and market analysis tool to the context of the Linux market in China. A series of strategies for the new rival, as well as strategies for the incumbent, are presented. Findings from this study suggest approaches not only for the context at hand, but also for other scenarios where open-source, network effects, software piracy, and extreme income variances exist.

Keywords

Adoption, diffusion, network effect, externality, piracy, open-source, Linux

INTRODUCTION

Microsoft Windows operating systems have dominated both the server and desktop (including workstation and laptop) software markets for many years. While exact figures vary slightly, nearly all agencies tracking desktop market share report that the various versions of Windows collectively continue to hold market share in excess of 90% worldwide. Windows server products also have a majority share of the server market, enjoying particularly strong growth in the last decade (Galli, 2007). But some have suggested the Windows monopoly is under threat by the open-source rival, Linux. Today, all major computer manufacturers sell computers with Linux pre-installed, and some foreign governments have encouraged Linux adoption. As such, application developers have rushed to support the platform. The onslaught is so substantial that Microsoft Chief Executive Steve Ballmer has named Linux as the firm's "top threat", and has referred to the software as a "cancer" that impinges on intellectual property rights (Kerstetter, Hamm, Ante and Greene, 2003).

As an open-source operating system, Linux can be revised and extended, requiring no licensing fees. In addition, the Linux platform, aided by the peer-review nature of open-source development, is generally believed to be highly stable, secure, scalable and powerful. Linux today powers platforms ranging in size from mobile phones to super computers. And while Windows maintains a commanding lead in server market share, Linux dominates key sub-segments, for example, powering the majority of publicly facing web servers (Galli, 2007).

Most of the Windows versus Linux debate has been cast in terms of which is technically better or cheaper. On the technical side, users and makers of the Microsoft and Linux operating systems have often clashed over usability and performance. Other features often cited include scalability, reliability, security, applications, drivers, and file system. It is generally believed that Linux outperforms Windows in performance, scalability, reliability, security and file system, while Windows offers much better user interface and many more applications (Yankee Group, 2007).

In terms of price, many believe that Linux-based operating systems have their best success opportunity in developing countries because many users in developing countries cannot afford proprietary software. In addition to choosing between licensed Windows or Linux that is essentially free, however, there is a third, although illegal option being exercised by huge segments of the world population: piracy. Because obtaining unlicensed Windows software is very easy and common in

developing countries, 'free' Linux competes with 'free' Windows, albeit in a way that damages the earning potential for commercial software providers. Does Linux have a chance to succeed against Microsoft Windows? The answer to this question is not just which is technically better or which is cheaper. Customer installed base, application availability, governmental policies, and other factors all play a role.

This paper presents a general valuation model for analyzing platform competition between an incumbent and a new entrant. The model is then applied to consider the specific case of Windows vs. Linux in China. In addition to price and technical features, the model considers *network effects*[1] and the diffusion of unlicensed software. This valuation model is then applied to develop a series of strategies to improve Linux adoption, as well as strategies Microsoft may deploy to secure a dominant position. The approach to consider emerging markets, open-source alternatives, and piracy all represent valuable contributions for both research and practice. Lessons learned can be leveraged in understanding platform competition in several markets. This work draws on extensive field visits with foreign and domestic tech firms in China, E. Asia, and the United States, as well as data from secondary sources.

LINUX VS. WINDOWS IN CHINA

Microsoft Windows operating systems dominate the desktop software market in China. There are several reasons for this success. *First*, many key applications and popular games, are only developed for Windows. *Second*, Windows operating system offers a user-friendly Chinese interface. *Third*, Windows has enjoyed a large installed base that results in greater compatibility benefit and has attracted the largest selection of software titles. Like many software products, operating systems are subject to network effects such that user base generates additional, technology independent benefits to its users (Farrell and Saloner, 1985; Oren and Smith, 1981). The strength of these network effects are reinforced by switching costs (e.g. learning, software investment, file creation, etc.). Working together, these characteristics create a winner-take-all or at least winner-take-most market dynamic that can be extraordinarily difficult for new entrants to break.

In contrast to the proprietary Windows software, Linux is an open-source operating system. Linux is capable of enhancement and generally requires no licensing fees. In addition, many believe Linux to be more stable, secure, scalable and powerful. Most industry observers, however, agree that Linux is not ready to mount a serious challenge to Windows in the desktop arena, although the operating system has made significant inroads in the server market and actually dominates many key segments. Because the base price for a Windows license is considerably high compared to the average Chinese income, and due to lax attitudes toward intellectual property, most experts estimate that at least 90 percent of the Windows operating systems in use are unlicensed copies (Kirkpatrick, 2007). Given a much smaller installed base, it appears to be very difficult for Linux to catch up on Windows merely based on price when unlicensed copies are readily available.

As China has entered the World Trade Organization (WTO) and agreed to fully comply with software licensing, it has encouraged government institutions and state-owned companies to use domestically developed software, in an attempt to reduce the risk of having China's software markets completely controlled by foreign firms. With Linux operating system, it is believed to have full transparency in terms of the underlying code, reducing the risk, for example, of relying on foreign software some officials fear may have "back doors" or other weaknesses that could compromise security.

In order to control its destiny in terms of the software platform that is used in the country, China government has endorsed products from Red Flag Software, the largest Linux software vendor, and has issued several other edicts favoring local firms. Red Flag was established in August 1999 by the China Academy of Science and state-owned Shanghai NewMargin Venture Capital. Red Flag has also received funding from CCIDNET Investment, a venture capital firm owned by the Ministry of the Information Industry. Red Flag software has also crafted partnerships with several domestic and international hardware and software firms. In addition to offering it's own Linux distribution, Red Flag also offers a software suite competing with Microsoft Office, that includes a spreadsheet, a Chinese-language word processor, graphics and other applications.

With support from the government and technology help from the Academy of Science, Red Flag Linux presumably will have more commercial opportunities and enjoy more favorable policies than other software makers. And as the recent struggles of US technology firms in China suggest, products tailored to Chinese consumers by local firms are more likely to be

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1 Network effects are also referred to as network externalities in the literature. We use both terms interchangeably throughout the paper. Network goods are products or services that are subject to network effects, such that a product will become more valuable as its user base expands and the compatibility benefit increases.

embraced[2]. As over half a billion people in China have not yet chosen their operating system, with many more likely to switch to the alternative, victory of one platform or another remains uncertain. Can Linux defeat Windows in China? What are the strategies for Linux camp? How would Windows respond to the challenge from Linux? To explore these questions, we develop a valuation model for analyzing platform competition in the presence of network effects. We then expand the model to compare the specific situation of Linux vs. Windows in China. We end by leveraging the model to consider various strategies that may be employed to foster Linux adoption in China, and strategies that Microsoft can leverage to maintain and develop its market dominance.

A VALUATION MODEL FOR LINUX AND WINDOWS

Software products, in general, and computer operating systems, in particular, are subject to network effects such that a software product will become more valuable as its user base expands (Farrell and Saloner, 1985; Oren and Smith, 1981). Thus, the foundation of our valuation model is a classical model of network goods (Farrell and Saloner, 1986; Saloner and Shepard, 1993) whose perceived value is expressed as:

$V = a + b(N)$

This model expresses the value (V) that consumers derive from a network product as a function of a, the "stand-alone" or "technology-dependent" benefit and $b(N)$, representing network effects. In other words, $b(N)$ is the technological compatibility benefit derived from a network of size N. Because the utility derived from a software product increases with its installed base, $b(N)$ is an increasing function of N. In many contexts, such as social networking products or services, $b(N)$ is arguably an exponential function of N that may result in *bandwagon effect* and the ultimate winner-take-all scenario. The explosive growth of FaceBook, MySpace, YouTube and Skype are familiar cases in point.

In the context of computer operating systems, "stand-alone" product features may include various types of functionality, as well as metrics for performance, reliability, scalability, security, and usability[3]. Network effects, on the other hand, may arise from benefits accrued from the installed base. We use the following general value function that accounts for various attributes for technical functionality, plus network effects:

$V = f(a_1, a_2 \dots, N)$

To further develop the model, it is recognized that the operating system is a *two-sided market* (Eisenmann, Parker and Van Alstyne, 2006) in that two components are necessary for the user to derive utility. In this case, the two components are the operating system and the software that executes within the operating system. Users care about the installed base of users of a particular platform, but they also value a product based on the number of complementary products that further enhance that platform's value. As such, a more granular model is expressed as:

$V = f(a_1, a_2 \dots, N^B, N^C)$

Where N^B represents an operating system's installed base and N^C represents the network size of complementary products available for the platform. N^C is an important variable in the valuation function as it also models the perceived risk of being stranded with an incompatible operating system. As a matter of fact, a new, better system may be considered worthless if it is perceived to be incompatible with indispensable application programs. Because the consumer's expectation of the viability and future success influences the perceived value of a network product (Shapiro and Varian, 1998), capturing a large installed base in both markets fuels a vicious cycle of network effects (e.g. more users attract more developers offering more software, which attracts more users…). The size of the installed base also plays a role in signifying the viability of a future platform. All else equal, consumers prefer a platform with a larger installed base when switching costs are present, as it signals continued viability, mitigating the risk of being stranded in an unsupported standard and having to incur the cost of switching to a rival effort (Arthur, 1994).

A necessary condition for a rational consumer to consider purchasing a network product is as follows:

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2 Examples include Yahoo, eBay, and Google in competition with Sohu, Alibaba Taobao, and Baidu.
3 The usability metric includes time and effort needed to install and configure the system. If a new system is perceived to be very difficult to install or use, potential adopters may consider it worthless, even if it is free of charge, because of high perceived adoption cost.

$P \leq W \leq V = f(a_1, a_2 \ldots, N^B, N^C)$

Where P is the price of the product and W is consumers' *willingness to pay*.

Within our context, consumers making purchasing decision would have to choose between two competing operating systems, Windows and Linux. A necessary condition for a rational consumer to consider adopting Linux is:

$V_L - P_L \geq 0$

or equivalently

$f(a_{L1}, a_{L2} \ldots, N^B_L, N^C_L) - P_L \geq 0$

where P_L is the price of Linux desktop operating system. Similarly, a necessary condition for a rational consumer to purchase Windows desktop operating system is:

$V_W - P_W \geq 0$

where P_W is the price of licensed Windows software.

In addition to product specific features and pricing, consumers must form expectations regarding the installed base of both networks and the associated externality benefit. In other words, consumers will need to compare two valuation functions before making adoption decisions. Consumers will opt for Linux if:

$V_L - P_L \geq 0$ (1)
$V_L - P_L \geq V_W - P_W$ (2)

Obviously another necessary condition is that the consumer must be able to afford the platform. Given that P_L is negligible for Linux[4], we let $P_L = 0$. Assuming $V_L \geq 0$, Equation (1) will hold true, and Equation (2) becomes:

$V_L \geq V_W - P_W$ (3)

In other words, a consumer will choose Linux over Windows if Equation (3) holds true. As a result, one can expect that the larger the value for V_L (the perceived value of Linux) and P_W (the cost of purchasing a licensed Windows operating system), the more likely the consumers will choose Linux over Windows.

There is one additional component to consider: switching costs. Technology adaptors in particular often incur adoption investments that far exceed the cost of the product or service alone. For example, users may acquire complementary goods, create files, and make significant time investments in learning a product or service. A move to a new platform implies that some or all of this investment may be lost. Switching costs can help strengthen a firm's network benefit by making it less likely that users will leave one standard for another. Switching costs also reinforce market bandwagons and the monopolistic tendency of winner-take-all and winner-take-most markets fueled by network effects (Gallaugher and Wang, 2002).

We can model the case where consumers would choose to adopt a free Linux operating system over the established Windows incumbent as follows:

$V_L \geq V_W - P_W + S_W$ (4)

where S_W is the switching cost a user incurs when moving from Windows to Linux. In this case, the new entrant (in this case Linux) can be superior and free, yet if network effects and switching costs are significant enough, the incumbent will still win.

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4 Although the actual Linux distribution may not be zero, it can be considered negligible compared to Windows.

We illustrate this model and competition among incumbent and rival platforms in Figure 1, where new entrants facing an entrenched incumbent will seek to improve various functions of its value equation. These include improving technical features, expanding its installed base, attracting complementary products, and producing adapters that can allow it to leverage complementary products of the rival and reduce rival switching cost advantages.

In studying platform competition in the video game industry, Schilling (2003) introduced the concept of 'technological leapfrogging', indicating that a rival will have to offer technical attributes that exceed not only the technical features of the incumbent, but the combined value of its installed base and complementary products. Our model extends Schilling's work in that we consider switching costs as well. In this expanded model, it is recognized that to win, technological leapfrogging is not the sole option. To win a market, an upstart may leverage strategies that try to grow each component of its own value equation, or shrink components of the incumbent's value advantage. Strategies for doing so follow.
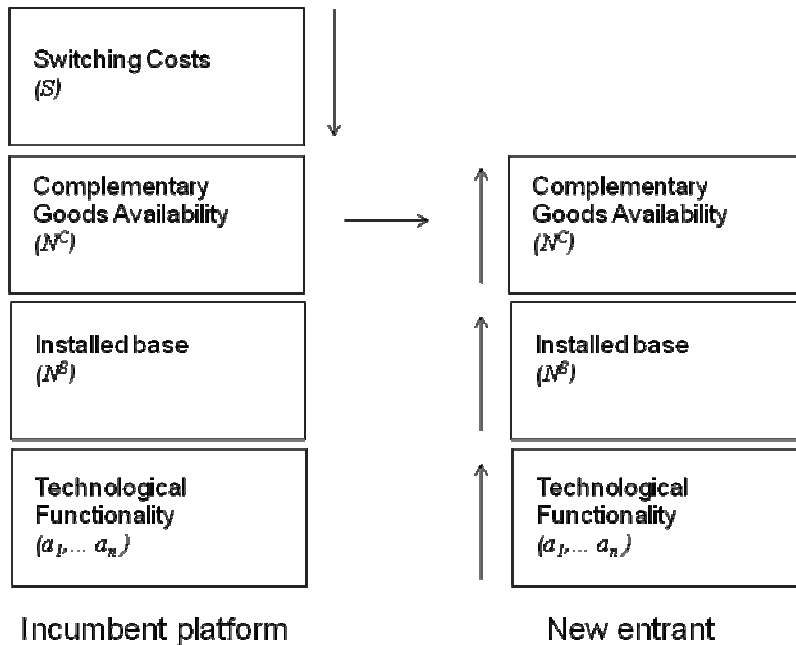

Figure 1: Value Components in Two-Sided Network Markets

STRATEGIES FOR INCREASING LINUX USE IN CHINA

We apply the valuation model presented earlier and discuss several strategies that the Linux camp may consider to increase its success likelihood.

Linux Strategy 1: Stringently Protect intellectual Property

The case of considering the adoption model in China is complicated because of rampant piracy. Experts suggest the over 90 percent of software in use in China may be pirated (Kirkpatrick, 2007). Because unlicensed copies of Windows software are readily available and essentially free, in the case of rampant piracy we observe that for most consumers $P_W = 0$. We also observe that since the Windows market is larger than the Linux market, in nearly all cases $S_W \geq 0$, a characteristic that further favors Windows. Thus, for today's China, as in much of the developing world, Equation (4), the necessary condition for a consumer to choose Linux over Windows, becomes:

$$V_L \geq V_W + S_W \qquad (5)$$

Similarly, given P_W and P_L are negligible, the necessary condition for a consumer to favor unlicensed Windows software is:

$V_W + S_W \geq V_L$ (6)

Recall that due to network effects, the much larger user base and more robust application selection of Windows creates more value for consumers and results in a greater perceived value, V_W. Because $V_W >> V_L$, Equation (6) will hold for most consumers, who will find unlicensed Windows more desirable than free Linux. Consequently, the diffusion of Windows software has been rapid in China. Because of network effects, one can argue that the diffusion of unlicensed copies of Windows operating systems and applications software resulted in a larger overall installed base for Windows than it would otherwise could. In fact, Linux purchased through Chinese pirates actually costs more than bootleg Windows because it comes on more disks (Kirkpatrick, 2007).

The conventional wisdom is that unlicensed copies of software deprive software vendors of profits, and Microsoft has been trying to enforce its intellectual property rights worldwide in order to prohibit distribution of unlicensed copies of Windows. Now that China has joined the World Trade Organization, the country is obliged to effectively curtail the use of illegal software. However, software piracy may actually help a firm grow its commercial installed base over rivals. Givon, Mahajan and Muller (1995), for example, formulated and tested a software diffusion model and showed that distribution of unlicensed copies increased the overall user base over time and altered product adoption rates, specifically increasing the "word of mouth" or external influence on potential purchasers. They concluded that distribution of unlicensed copies resulted in "shadow diffusion" in parallel to legal diffusion, and due to network externalities, shadow diffusion in fact contributed to legal diffusion. While piracy in China is not profitable for Microsoft, it has almost certainly helped the firm establish and strengthen a leadership position over alternatives. Microsoft faces a dilemma wherein it must balance the threat of piracy with the positive network effects due to the diffusion of unlicensed copies.

This creates the curious scenario whereby Linux backers promoting Intellectual Property (IP) rights that ostensibly protect the value of Windows as dominant for-fee incumbent, would actually work to increase Linux share. Such an aggressive stance in support of copyright enforcement is not an anathema to open source. The movement respects intellectual property and leverages various legally binding licensing agreements to protect IP. Indeed several public corporations stake their competitiveness on open-source software (e.g. IBM, Novell, Red Hat, and Sun), each of which has a high commitment to worldwide IP enforcement. However, in all of these cases, open-source firms rely on a business model that differs from that used by Microsoft (e.g. open-source adoption nurtures a market for hardware, support, and service revenues). A stringent enforcement of copyright laws in a way that severely penalizes and discourages piracy would particularly favor the open-source movement in developing countries. It is because enforcement in cases where commercial products are highly costly compared to discretionary income may push some consumers toward legal, but free or lower-cost alternatives.

It has been estimated that the affordability point for a PC is when it is 20 percent or less of annual income (Yates, 2007). At developed-nation rates, the cost of Windows adds roughly $100 to each PC, and that can be enough to keep personal computing beyond the economic reach of many individuals. Add the additional cost of application software to this figure and the digital divide widens. If users who are inclined to pirate today find that they are unable to do so in the future, wide swaths of the population will turn to free, open-source alternatives. Recognizing this, aggressive enforcement of China's mandated IP protection should favor the nation's open-source providers. In fact, there was a reported 25.1 percent spike in Linux installs in Q3 2007 as China's antipiracy movement had an effect (Yang, 2007).

Linux Strategy 2: Increase the Installed Base of Users Running Linux Desktop Software

Increasing the installed base of users not only improves the exchange benefits reaped by the user base, it also acts as an attractant for additional software vendors to offer products for the platform. This positive feedback loop is the realization of network effects. But jumpstarting the network effect, particularly when competing with an established rival, is extremely difficult (Schilling, 2003, Shapiro and Varian, 1999). However, the Chinese government has emerged as a major force promoting the development and use of open-source software. In 2004, the Chinese Ministry of Information founded the Open Source Software Promotion Alliance to encourage the development of China's open-source software industry (Marson, 2005). The government is also working with a number of other countries on open-source projects, including Asianux, a joint Linux initiative with South Korean and Japan, and a Linux-based platform for online services and communication applications with the French Atomic Energy Commission.

Several public announcements and policy mandates underscore the Chinese government's efforts to encourage the adoption of open-source software. For example, in 2003, the State moved to require the use of China-produced software in government departments. The announcement stated that the government would only purchase hardware preinstalled with

domestic operating systems and applications. Those seeking exceptions would need to submit a special request (CNet 2003). In another example, in 2004 the Pinggu regional government began to push the use of open-source software. By 2007, 85 percent of the region's government computers installed Linux. In what was billed as the largest Linux desktop rollout in Asia, the Jiangsu government announced plans to put more than 140,000 Linux PCs in primary and secondary schools across the province (Marsden, 2005). Moves to encourage platform use at work and school can be particularly impactful, as users who are familiar with one computing environment may be more likely to adopt that platform for home use. Security concerns play an increasing role in governmental open-source promotion efforts, as well. Chinese officials have repeatedly expressed a pronounced distrust with reliance on proprietary technology for sensitive functions. Such attitudes are not limited to the Chinese.

Opportunity exists in situations where the existing Windows installed base is low, and communication with individuals on proprietary platforms is limited. However, even China's bold initiatives have met challenges. Reports suggest that the law to use Chinese software has not been strictly enforced throughout the government (Kirkpatrick, 2007). For example, Beijing has reportedly bought a "substantial quantity" of Microsoft software even after this directive, many of Shanghai's offices have also opted out. And despite the Pinggu Linux initiative mentioned above, 53 percent of those machines dual boot with Windows as well as Linux because so many government offices continue to use Microsoft products (Yang, Jan. 2007). These struggles underscore the power of switching costs in standards battles.

Linux Strategy 3: Develop and Enhance Adaptors

Switching costs can be a key competitive advantage for an incumbent. However, switching costs can be combated by leveraging adapters to promote product compatibility. Within the context of the presented model, an adapter can substantially decrease the switching cost component S_W, reducing the perceived overall value of Windows V_W. This is because an adaptor would allow Linux machines to run Windows software (reducing the unique advantage of the complementary goods for Windows by making these products available to accrue value benefits to Linux.

When well-executed, compatibility can neutralize one of the key strategic assets of an incumbent. To some extent this is visible in Apple's more than doubling the US Macintosh market share in two years after the switch to the Intel platform. Macs now enjoy several options of running Windows in either separate boot or virtualization mode. Hardware in support of Windows execution is not the only form of compatibility; file compatibility in office-suite products is also important. Windows file compatible office suites have long been available for Linux and Macintosh, respectively. However, it was not until Windows applications could execute natively on Apple hardware that the Macintosh market began to accelerate most dramatically.

Several efforts to run Windows applications natively within other operating systems exist in various stages, although all suffer limitations. Perhaps the best known is Linux's WINE (the recursively named Wine Is Not an Emulator), inspired by the earlier WABI effort (Windows Application Binary Interface) from Sun's Solaris. WINE has continued to improve, recently adding support for Windows DirectX graphics package. While at least one study suggests WINE is used by over 30% of Linux desktop users (DesktopLinux.com, 2007), stability concerns caused the Linspire (formerly Lindows) based PC sold at Wal-Mart to abandoned the goal of Linux-based Windows support in favor of natively offered applications (Newton, 2005).

A concerted effort to develop and strengthen native Window application execution support under Linux would remove much of the switching cost and complementary product value advantage that enable Microsoft to extract a Windows price premium beyond the technological functionality of the feature set. Allowing users to legally run Windows applications without the Windows operating system would lower the cost of PCs and fuel Linux adoption to the most price-sensitive consumers.

Linux Strategy 4: Enhance Desirable Product Features

As discussed earlier, the perceived value of Linux can be expressed as:

$V_L = f(a_{L1}, a_{L2} \ldots, N^B_L, N^C_L)$

where "stand alone" (technology-dependent) product features include performance, usability, scalability, reliability, security, and file system.

In addition to cost savings, some of the claimed strengths of Linux include performance, reliability, scalability, interoperability with existing systems, and security (Yankee Group, 2008). For example, Windows has to overcome its crash-prone history while Linux's reliability is rock solid and should only improve. Peer review prompts the Linux community to quickly recognize weaknesses and fix bugs (the saying among open-source developers is "with enough eyeballs, all bugs are shallow", Raymond, 1999). And Windows suffers from a downside of the network effect. While developers are attracted to platforms containing the largest user base, this applies to black hat hackers that write viruses and worms, as well. Technical advantage isn't exclusively the domain of Linux, however. Windows offers much better user interface and is easy to install and setup. On the contrary, many users perceive Linux to be more difficult to install and use, and require more time and effort to setup, reducing the perceived value of a new, essentially free system that may be better in many other areas. Currently, Chinese-language Linux-based operating systems are far from matching Windows' ability to cater to the average computer user in China. Chinese language versions of the Windows operating system remains the most widespread, user-friendly software in the Chinese PC market, and most users are likely to stick with whatever is most convenient.

To help users get over the learning curve, the Linux community must focus on enhancements that close the usability gap with Windows. A strategy to pre-load Linux and desirable application titles with shipping hardware will, minimally, address installation concerns for those making a operating systems platform as part of hardware selection. Leverage of this strategy is already underway, as China's three largest PC firms, Lenovo, HP, and Dell, have all moved to pre-install Linux on PCs sold in China.

Linux Strategy 5: Develop More Applications

Linux must work to improve the user experience, particularly if it is to penetrate end-user computing markets. This would work to improve technical functionality. While offering a reliable emulator would allow Linux to take advantage of complementary goods available to Windows, reducing Microsoft's ability to exploit this asset, Linux advocates can also seek to increase complementary goods on their own platform, improving the factor expressed as N^C_L. More applications would work to improve the network effects-based appeal of the platform, increasing the user installed base, N^B_L, which should further increase the number of applications available, N^C_L.

The Chinese government has played an active role in promoting non-Microsoft software alternatives, many of which are open-source software or which run under Linux. For example, the government's preferred list of office products includes NeoShine, a Chinese variant of OpenOffice.org (Marson, 2005). A special congress was also held to encourage ministries to upgrade to WPS Office, a China-made office productivity suite by PRC based Kingsoft (CNet, 2003). While the Linux version of WPS Office is a commercial product, it sells for a fraction of the cost of Microsoft Office. Increased anti-piracy measures have prompted many government offices switched to WPS from pirated versions of Microsoft Office. For example, following an anti-piracy raid on Shanghai Schools, the district unanimously adopted the less expensive WPS Office suite (CNet Asia, 2003). Lean operating Chinese firms can also leverage their cost advantage when developing revenue strategies. Worldwide, Windows currently enjoys 74 percent average margins. Chinese firms operating with less overhead, lower labor costs, and that can leverage government demand generation instead of costly sales and marketing efforts, would be able to offer product at a price point well below that demanded by foreign commercial offerings. New revenue models, such as ad-supported software and micro-payment strategies may also prove more viable in China's low-overhead environment, and more attune to compete in a culture that still tolerates piracy.

There are unique opportunities to cultivate a user base in products where markets have cultures distinct from the incumbent. eBay, for example, has failed to leverage its network effects when entering foreign markets even just a few months short of rivals (Sellers, 2004). The firm's attempts to enforce the US design aesthetic on its EachNet China acquisition was credited in part for the firm's fall from an 80 percent share to less than 30% in two years. The firm has since abandoned EachNet, after pouring more than $300 million into attempts to win the Chinese market. EachNet's loss was Alibaba Taobao's gain. The now publicly traded firm has a majority share in China, gains largely attributed to page designs and operations that appeal directly to the uniqueness of the Chinese consumer (Bradsher, 2006). The success of Motorola's China-specific Ming mobile phone (which incidentally runs a version of Linux for phones) attests to the potential for designing products specifically targeted at Chinese consumers (Bremner, 2006).

MICROSOFT STRATEGIES

The incumbent is not defenseless against these strategies. Below we examine the potential strategies Microsoft can deploy to defend and expand its competitive position in China.

Microsoft Strategy 1: Price Discriminate to Expand the Market

An incumbent faced by the threat of the strategies outlined earlier will find the consumer value of the rival increases. In the case of Linux in China, these strategies work to improve Linux's network effects from installed base and complementary product availability, switching costs, and features. Should this happen, Chinese consumers will focus even more acutely on Microsoft's significant price premium. Recall in Equation (4) that users will adopt Linux if $V_L \geq V_W - P_W + S_W$. Price-based competition may be particularly threatening to Microsoft. Annual income in China averages less than \$500/year (Hruska, 2007). Demand for low-cost computers has prompted Dell to offer a Chinese PC for less than \$230, and Lenovo to market one for \$199 - each offering Linux pre-installed. While these PCs could theoretically run Windows, Linux generally performs better on less expensive, low-end hardware. It is also noted that Linux is the native operating system for the OLPC (the so-called \$100 laptop).

An incumbent facing increased price-focused competition resulting from successful strategic incursion by a rival may choose to price discriminate to hold or gain market share. This would involve offering products at lower costs in targeted markets. This is the response taken by Microsoft in its decision to offer a bundled Starter Edition of Windows along with MS Office Home and Student, Microsoft Math 3.0, Learning Essentials 2.0 for MS Office, and Windows Live Mail desktop for roughly \$3 per machine (Hruska, 2007).

Leveraging this strategy, the incumbent firm forgoes income in the developing market in the short term, in the hope of cultivating strategic assets of network effects and switching costs over the long-term. Such move may also be logical and strategic in order for Microsoft to maintain the dominant market position on Office and other software products. Chinese incomes are rising rapidly, and at some point Microsoft will gain an ability to raise prices in China. Until then, the firm has the luxury of using profits in other markets to fund competition in what will soon be the world's largest market. Further, all of this allows the firm to continue to lobby for increased piracy enforcement while parrying accusations that it is forcing Chinese consumers to pay exorbitant prices. Indeed, the lower price allows Microsoft to leverage Internet-based mechanisms such as Windows Genuine Advantage to certify that all software copies are legitimate. While the new pricing policy nets Microsoft an average of just \$7 on every PC sold in China, projected sales in 2007 were three times greater than in 2004 (Kirkpatrick, 2007).

Microsoft Strategy 2: Selective Enforcement

A variant on the mechanism above is worth mentioning. Microsoft could not only price discriminate but selectively enforce copyright with those organizations most capable of paying. Government offices, large Chinese firms, and foreign multinationals are all much more able to afford software than the average Chinese citizen. Selective enforcement and offering a two-tiered pricing scheme would allow Microsoft to harvest revenues from those most able to pay, while tolerating a "shadow market" among end-users that maintains network effects and builds an installed base that becomes increasingly entrenched with switching costs over time. Again, as income improves, the firm will eventually be positioned to more aggressively enforce software licensing with home users.

Microsoft Strategy 3: Enhance Product Features

The adaptor strategy is most threatening because it reduces the switching cost advantage of Windows as an incumbent, as well as its advantage in terms of complementary products. In Microsoft's case, a high-quality adapter capable of running Windows software within a free operating system eliminates this critical advantage. Incumbents faced with rival attempts to craft an adaptor are well-served by continual product improvement, particularly in ways that 'break' adaptors. Users that find adaptors like WINE to be less compatible than the alternative of running Windows are more likely to adopt Windows instead of Linux. Product enhancement, particularly targeted at the unique needs of local consumers, is a way to improve product feature. Microsoft's moves to increase software development in China should help the firm develop products that meet the needs of the growing Chinese market.

Microsoft Strategy 4: Offer Openness to Address Security Concerns

Several reports suggest Chinese officials are leery of relying on Western-developed products for sensitive government, military, and commercial applications. A firm faced with losing market share based on perceptions that its product is a 'black box', closed to analysis and review, may respond by becoming more open. Microsoft appears to have leveraged just this tactic. The firm now offers China (and 59 other countries) the right to examine large portions of Microsoft source code, and even allows for the modular substitution of certain functions with government-approved alternatives software. This would enable, for example, China to use internally developed cryptography (Kirkpatrick, 2007).

Microsoft Strategy 5: Invest in Local Firms

Investments in local firms have several critical benefits. First, this allows the firm to cultivate the market for indigenously developed third-party software. Locally developed products are also more likely to be attuned to the local market. By cultivating a local software industry, the firm is able to increase the number of Chinese firms to joint it for lobbying for increased intellectual property protection. Governments will recognize the value of IP protection as larger portions of its economy are based on IP. Microsoft has committed over \$165 million to investments in Chinese software firms. It has also gone as far as inviting government officials to help decide which firms to invest in (Kirkpatrick, 2007). These tactics move the incumbent from being perceived as an IP bully to a role as a catalyst for local market development and technology transfer.

CONCLUSION

Rival operating systems have long battled with software giant Microsoft for a greater market share. Now, it seems that Linux is mounting a credible threat in emerging markets, especially China. Several factors make competition with Linux troublesome for Microsoft. These include the increasing quality, power and expandability of the rival platform, governmental security and political concerns and policies that favor local firms, and the comparably lower available disposable income of would-be purchasers. Plotting strategy is further complicated by rampant software piracy.

This paper developed a theory grounded, strategic valuation model for two-sided markets where network effects and switching costs are present. The model was then expanded to consider pricing factors related to open-source software and piracy. The model was next applied to the context of competition in the Chinese market for computer operating systems, specifically considering Linux vs. Windows, by far the most credible and influential rivals in the sector. Finally, the model was used to create a series of strategies for the new rival, as well as strategies for the incumbent. Actions from several constituents in the Chinese software market, including state government agencies, as well as domestic and foreign hardware and software firms are examined. The model explains competitive actions among the players, and suggests additional strategies for market incursion and defense.

Findings from this study suggest approaches not only for the context at hand, but also for other scenarios where two-sided markets, open-source, piracy, and extreme income variances exist. This work could be further expanded to study new contexts, such as new technology platforms as well as social network products and services. Future research may also consider ways to operationalize the models herein for further examination and testing of competitive factors.

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