Two-sided competition of proprietary vs. open source technology platforms and the implications for the software industry[1]

Nicholas Economides[2] and Evangelos Katsamakas[3]

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Introduction

Technology platforms are the hubs of the value chains in technology industries. Some examples of technology platforms are Microsoft Windows (PC operating systems), Intel processors (PC hardware), the Palm operating system (handheld devices), and the Sony PlayStation (game consoles). The firm that becomes a platform leader and controls a platform, such as Microsoft in the PC operating systems market, can maintain a strong position in the industry but also faces the challenge of managing the evolution of the platform.[4]

A firm that controls a platform makes strategic decisions, such as on pricing and technical compatibility, for the products it sells directly to end users as well as with respect to products sold by other firms that are complementary to its platform. We call this "two-sided platform pricing." For example, firms that control game consoles set a price for the game console and often charge royalties to developers of games, following a two-sided pricing strategy. In another example, Microsoft effectively subsidizes application developers by including in Windows functions that are useful to application developers and not directly useful to end-users. We will focus on the ability of the platform firm to use pricing strategically so as to influence the complementary goods markets. This has not been sufficiently analyzed in the earlier networks literature.

Sometimes a technology platform is not proprietary. For example Linux, an emerging operating system, is open-source. In this paper, we also analyze the strategic differences between proprietary and open source technology platforms, and characterize the implications for the structure of the software industry. We present models that study the following research questions:

- What is the optimal two-sided pricing strategy of a proprietary platform? Under what conditions does a platform firm set a positive or negative fee to providers of complementary applications? What are the implications of the existence of such a fee? How does the degree of complementarity between the application(s) and the platform affect the platform's pricing strategy?
- How does a proprietary software industry compare to an open source software industry with respect to industry pricing, sales, profitability, and consumers' and total surplus?
- What is the structure of competition between an open source platform (e.g. Linux) and a proprietary platform (e.g. Windows)?

We develop models that extend the systems and economics of networks literatures and provide a framework to answer the above questions. A core strategic question for a platform leader is how collaborative vs. competitive should its relationship be with providers of complementary goods. Our framework provides an answer to this question in terms of access fees vs. subsidies set by the

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[2] Stern School of Business, N.Y.U., 44 West 4th Street, New York, NY 10012, (212) 998-0864, neconomi@stern.nyu.edu, http://www.stern.nyu.edu/newtorks/

[3] Graduate School of Business, Fordham University, 33 West 60th St, NY 10023, katsamakas@fordham.edu

[4] See Gawer and Cusumano (2003), and Cusumano (2004).

platform firm. Our models allow for complementarities between the platform and each application and at the same time users have a preference for application variety. Thus, an increase of the size and sales of the applications network increase the demand of the platform.

We find that the equilibrium prices for the platform, or the applications, and the platform access fee for the applications can be below marginal cost, and we characterize conditions for each of these events to occur. We find that the platform firm subsidizes the application when the demand of the platform is stronger than the demand for the application(s), or when the own-price effect of the platform is weak relative to the complementarity between the application and the platform. The platform firm subsidizes the users of the platform when the demand of the application is strong relative to the demand for the platform, or the own-price effect of the application is weak relative to the complementarity between the application and the platform. The application firm subsidizes users of the application when it receives a large subsidy by the platform firm. We find that the platform is less likely to subsidize them if the substitutability between the applications is strong. When more than one application uses the same platform, we determine how the interaction between the applications in terms of complementarity or substitutability affects the equilibrium. We show that it is important to analyze the whole system of prices to determine the appropriate public policy. When the study focuses only on a part of the system, significant features of the strategic interaction in the industry are neglected or may remain unexplained.

A two-sided pricing strategy always increases the profits of the platform compared to the one-sided pricing strategy profits. However, the additional value to the platform of using the two-sided pricing strategy can be small depending on the market characteristics and it may not offset the costs of implementing it. The two-sided pricing strategy increases the profit of the application provider only when the application is subsidized by the platform. However, the two-sided strategy often reduces the social surplus and the consumer surplus. There is also a region of parameters for which the two-sided strategy decreases total industry profits (of the platform plus application(s)).

We use the two-sided pricing framework to compare a software industry based on a proprietary platform with a software industry based on an open source platform. For the open source platform, we assume that the operating system charges a zero price for the operating system as well as a zero access fee to applications and therefore makes zero profit. However, application(s) compatible with the open source operating system can be proprietary and typically make positive profits. This can give significant incentives to firms like IBM to promote an open source platform such as Linux for which IBM provides proprietary applications.

We find that the social welfare is higher (respectively lower) when the platform is open source and the cost of adopting the open source platform is small (respectively large). The open source industry is also more profitable than the proprietary industry when the demand of the proprietary platform is not much stronger than the demand of the application and the own-price effect of the platform is strong while the own-price effect of the application is weak. We also find that the total welfare of the proprietary industry with independent ownership is higher than the total welfare of a vertically integrated proprietary industry if the platform firm subsidizes strongly the application firm under independent ownership.

When the platform has a network of N independent applications, then the platform profit and each application profit is increasing in N. The access fee paid by each application is decreasing in N only when the users have a strong preference for application variety. The proprietary software industry is more profitable than the open source industry, if the users have a strong preference for application variety.

When a proprietary system (platform and independently produced application) competes with an open source system, the open source system is typically dominant in terms of market share. The proprietary system cannot achieve more than 30%-40% market share, and the market share of the application for the proprietary platform can be as low as 15%. The profit of the application provider for the open source platform is higher than the profit of the proprietary system when the degree of substitution between the systems is strong (differentiation is low), or the strength of complementarity between the platform and the application is strong.

There are a number of future research directions that can extend the model developed in this paper. First, one can analyze the incentives to invest in the platform and the complementary applications under different software industry structures, and we have some preliminary thoughts on this. Second, future research should analyze competition between an open source system and a vertically integrated platform that also provides applications. Third, future work can make the size of the network of applications for each platform endogenous and study the implications for the competition between the proprietary platform and the open source platform.

Related Literature

The paper is related to the academic literature on three topics: on systems, on the economics of the open source software, and on the literature on two-sided markets/networks.

The systems literature studies settings where consumers value systems composed of complementary components. The emphasis is on the implications of compatibility, the incentives of rival firms to make their components compatible, the effects of different ownership structures and the implications of bundling. Matutes and Regibeau (1988) and Economides (1989) study the incentives of firms offering symmetric competing systems, each comprised of two components, to make their systems compatible. They show that compatibility is the unique equilibrium. Economides and Salop (1992) study the effect of different ownership structures in a systems duopoly setting. Joint ownership internalizes the vertical externality (which tends to decrease prices), but also internalizes the horizontal/competitive externality (which tends to increase prices). Therefore, when the systems are close substitutes the equilibrium prices may be higher under joint ownership than under independent ownership. Farrell and Katz (2001) show that the integration of a monopolist into a competitive complementary market may weaken the innovation incentives of independent firms. Complementary components are typically assumed to be symmetric in the systems literature. Thus, previous research has not given much attention to a setting in which the components are asymmetric and the core component (platform) sets access fees or subsidizes the other complementary components that compose the system. This paper extends the systems literature by characterizing the platform strategies in such a setting and the implications for the system equilibrium.

The economics literature on open source focuses mainly on the individual incentives to participate in open source projects, the incentives of firms to adopt open source initiatives, the business models of firms operating within the open source landscape, and the competitive implications of open source software.[5] Johnson (2002) models the contribution to an open-source project as a problem of private provision of a public-good and analyzes the effect of increasing the number of developers. Lerner and Tirole (2001, 2002) discuss the incentives of individual programmers and software firms to participate in open source projects. They argue that programmers are motivated by "peer recognition" and delayed career benefits such as being hired

[5] Raymond (2001) provides an overview of open source software.

by a software firm, or getting access to funding for future software ventures. Firms participate because they make money from complementary applications or services, get access to development talent that they may hire in the future, learn about the competition and open-source technologies that they may use in the future, or to promote open standards (possibly competing to other proprietary standards). Mustonen (2003) proposes a model in which the participation of programmers in open-source projects is endogenous and shows that a low implementation cost of an open-source application is crucial for its survival when it competes with a proprietary application. Our paper focuses on the operating system as a platform. It departs from the above literature by considering the strategic differences between an open source and a proprietary platform and analyzing the implications for the structure of the software industry. The closest paper to this one is Casadesus-Masanell and Ghemawat (2003) that studies competition between Windows and Linux. However, that paper does not consider the two-sided strategy of Windows as a platform since it takes into account only the user price of Windows and ignores the strategy of Microsoft toward the complementary applications, which is crucial in our model.

The recent two-sided markets/networks literature focuses on pricing strategies in platform settings such as payment systems or intermediaries that facilitate matching of two discrete sides, such as content providers and content users. The typical modeling approach is to focus on the prices set only by the platform[6] and to study the effects of different cross-side network effects and different ownership structures on equilibrium prices of the platform firm, on competition between platforms, and on social welfare.[7]

Our model contributes to this literature stream by characterizing the microstructure of two-sided platform pricing in technology industries such as software. We follow the micro-approach in the networks literature (Economides 1996) and show how the cross-side network effects emerge.[8]

In our analysis, we show an equivalence between a specification that assumes complementarities and a specification that assumes explicit network effects across the two sides of the market (users and application providers), thus confirming the close relationship between the two-sided networks literature and the systems literature.

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[6] Therefore prices such as the price set by application providers are abstracted away, while these prices are endogenous in our model.

[7] See Armstrong 2002, Parker and Van Alstyne (2002), Rochet and Tirole (2003), Katsamakas and Bakos (2003), among others.

[8] In contrast, the macro-approach that is followed in the existing two-sided markets/networks literature assumes the existence of network effects and studies their implications.

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