HOW OPEN SHOULD AN OPEN SYSTEM BE?
Essays on Mobile Computing

by

Kevin J. Boudreau

B.A.Sc., University of Waterloo
M.A. Economics, University of Toronto

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Signature of Author .....
Sloan School of Management
3 May 2006

Certified by .....
Rebecca Henderson
Eastman Kodak LFM Professor of Management
Thesis Supervisor

Certified by .....
Michael Cusumano
Sloan Management Review Professor of Management
Thesis Supervisor

Certified by .....
Marc Rysman
Assistant Professor of Economics, Boston University
Thesis Supervisor

Accepted by .....
Birger Wernerfelt
J. C. Penney Professor of Management Science and Chair of PhD Committee

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Abstract

"Systems" goods–such as computers, telecom networks, and automobiles–are made up of multiple components. This dissertation comprises three esssays that study the decisions of system innovators in mobile computing to "open" development of their systems to outside suppliers and the implications of doing so.

The first essay considers this issue from the perspective of which components are retained under the control of the original innovator to act as a "platform" in the system. Based on detailed review of leading systems in this industry in data spanning 1984-2004, I find that platform boundaries expand and contract over time as a means for platform suppliers to promote the adoption of the platform (by end-customers, downstream manufacturers, and suppliers of complements) and simultaneously to ensure the continuing innovation of the system.

The second essay provides a systematic empirical investigation of how the extent of openness chosen by the platform supplier affected the rate of innovation of mobile computing devices. I measure openness in relation to both the boundaries of the platform and the extent to which actions were taken by platform suppliers to promote entry by hardware device manufacturers. I find regular relationships across multiple measures of innovation that suggest that the whether openness increases or decreases innovation depends on the nature of innovation and the intensity of competition between device makers.

The third essay moves from device hardware to the applications software developer networks that form around opened platforms. I investigate the effect of platform suppliers' aggressive promotion of entry of software developers around their platforms. I find that while large developer networks are associated with a wide selection of software titles, that very large developer networks in fact lead to less software output. I interpret this result as revealing the importance of maintaining investment incentives–even in a context with network effects.

Thesis Supervisor: Rebecca Henderson
Title: Eastman Kodak LFM Professor of Management

Thesis Supervisor: Michael Cusumano
Title: Sloan Management Review Professor of Management

Thesis Supervisor: Marc Rysman
Title: Assistant Professor of Economics, Boston University

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Chapter 1

Introduction

> "*The problem was the industry wasn't measured by who has the best selling personal computer or who has the most innovative technology. The industry was measured by who had the most open system that was adopted by the most other companies and the Microsoft strategy ultimately turned out to be the better business strategy*"
>
> - John Sculley, as appearing in "Triumph of the Nerds: The Rise of Accidental Empires" Public Broadcasting Service (airing June 1996)

> "*Telecommunications used to be a closed game... Now, openness reigns.... Networks must interconnect with those of competitors and users can plug in their own devices as they will. One result of this openness has been a lot of innovation.*"
>
> – The Economist (January 8 2005)

The problem of choosing a best way to organize production (Richardson 1972; Williamson 1975; Grossman and Hart 1986; Teece 1986; Becker and Murphy 1991) becomes particularly challenging in "systems" industries—such as automobiles, information technology, aerospace, consumer electronics, and media products—where multiple components come together to form the final product or service. Apart from their often extraordinary scale and complexity (Marschak 1962), these industries are also often affected by exotic market conditions such as network effects, winner-take-all dynamics and other issues that interact with organizational decisions. In cases where a system is first innovated by a lone innovator who maintains property rights over

the system or where there is a platform supplier with market power (often the original innovator), the decision of how to organize these industries often falls to that party. It is primarily from the perspective of this original innovator or platform supplier that the question of how to organize a system is considered in this dissertation.

Today, the menu of options of how to organize production of a system is understood using the metaphor of pursuing an "open" or "closed" strategy. This description has traditionally been used to describe relatively clear-cut situations, such as the development of a public telecommunications standard to be maintained by a public institution for all to use or a proprietary system to remain secret and used exclusively by its developer (closed) (Katz and Shapiro 1986, 1994; David and Greenstein 1990).[1] On the basis of these stark distinctions, theory and experience have revealed that giving up property rights and guaranteeing the free entry and use of a technology can promote adoption adoption by reducing the threat of "lock-in" or hold-up of buyers (Shapiro and Varian 1998),[2] by allowing multiple suppliers and buyers to coordinate on the same technology (Cusumano, et al. 1992; Grindley 1995; Augereau, et al.2005), and by increasing mix-and-match benefits to users available in multi-vendor systems (Matutes and Regibeau 1988; Baldwin and Clark 2000). Of course, giving up property rights and allowing outside suppliers to enter also leads an innovator to lose its monopoly over the technology (Katz and Shapiro 1996; Economides 1996; Kende 1998). Given such high costs in lost appropriability, both research and practice has traditionally focused on the strategic decision to open a system in extreme cases of winner-take-all competition, where an innovator might be moved to pursue a "large share of a small market" in the case of a closed system or a "small share of a large market" in the case of an open system (Shapiro and Varian 1998).

1.1 Open Questions on "Openness"

In the current usage, however, the metaphor of openness appears to have become woefully overburdened in describing and prescribing the organization of modern technology systems. Rather than clearly distinct cases of devolving property rights and free entry versus tightly

[1] In earlier literature the favored terms were "sponsored" versus "unsponsored" systems.

[2] The counter-argument, that an "unsponsored" technology may recieve less strategic investments and promotion of adoption through subsidies (Katz and Shapiro 1986) receives considerably less attention.

held property rights and foreclosed entry, "open" now casually describes a long list of issues in technology design, contracting and ownership choices. Is a computer language that is widely distributed and able to interact with multiple computer platforms–but over which ownership is maintained–"open"? Is a royalty-free music standard that forces conformance to certain technical rules and digital rights management "open"? Is an operating system that is informally governed, but governed nonetheless by an elite set of programmers "open"? Is a public communications network that has a government as benefactor and keeper truly "open"? Is a good sold at zero price "open," independent of other considerations? Is a system with some, but not all, components opened while others remain proprietary really "open"?[3] These scenarios suggest there might be different modes and degrees of openness–or simply there are multiple relevant technical and contractual instruments through which systems industries are organized and governed. Whether the application of these instruments is or should be so correlated as to allow a simple description along the continuum of open to closed remains unknown and under-explored.

Apart from the metaphor and its meaning, the theory also appears strained. Numerous scholars have begun to present evidence suggesting that openness also affects the continuing technical change and innovation of a system.[4] Given the radical reorganization of production implied by opening a system, it perhaps should not be surprising that the opening of a system might affect the rate–and possibly direction–of technical change in a system. Perhaps more surprisingly, the bulk of the empirical findings seem to suggests that openness tends to have a positive effect on innovation (Langlois 1992; Baldwin and Clark 2000; von Burg 2001; Chesbrough 2003; von Hippel 2005).[5] Might there be instances in which openness in fact hurts innovation? How would we know? Would it depend on the type or mode of openness in question? These issues also remain under-explored.

[3] West (2004) surveys several of the issues.

[4] Systems industries are often associated with an on-going stream of new products and components embodying novelty, technical advance and declining costs (Langlois and Robertson 1992; Bresnahan and Greenstein 1999; Cusumano and Gawer 2002)

[5] Early theoretical models on the topic suggests a more contingent view of the effect of openness (Farrell and Katz 2000; Becchetti and Paganetto 2001; Nahm 2004).

1.2 Dissertation Overview

This collection of three empirical essays attempts to make progress in understanding how systems industries should best be organized by empirically studying the mobile computing industry (i.e. handheld computers and smartphones). The relatively clear-cut and comparable structures across multiple systems and years in this industry provided a unique opportunity for building large scale datasets.[6] The analysis largely takes the perspective of the original innovators cum platform suppliers, intepretting the rationales and effects of their attempts to arrange the structure of production so as to create value, appropriate a fraction of that value, and allow the system to compete successfully against other systems in the market.

The first essay provides a rich historical description of the motivations and context for leading platform owners to give up control of different components in their systems at different times. In this essay, I focus on a most basic definition of openness–control over individual components in the system by the system innovator cum platform supplier–and study the motivation for retaining or giving-up control over these components (and, by implication, the boundaries of the platform). I find that shifting platform boundaries reflect attempts to negotiate tensions between goals of 1) retaining appropriability over the system; 2) promoting network effects and adoption dynamics; and 3) promoting innovation. The promotion of innovation sometimes involved closed strategies to achieve greater coordination; in other instances open strategies promoted external innovation.

The second essay provides a systematic investigation of the relationship between the extent of openness of systems and innovation outcomes with detailed data on the advancing attributes of hardware devices released in competing systems. In this paper I argue that increasing the openness of a technology—in terms of devolving control and granting access—should create tensions between promoting investment incentives, creating diversity in the supplier pool and promoting the efficacy of the coordination regime. The openness-innovation relationship is studied using a novel panel data on multiple dimensions of innovation in handheld computers and smartphones built "on top" of competing platforms of varying degrees of openness. Con-

[6] Prior empirical work on the supply-side of systems industries has relied on extensively detailed case studies, likely a result of limited numbers of competing systems, complexity of industry structure being studied and practical data collection limitations.

sistent with predictions, I find the sign and magnitude of the openness-innovation relationship depends on the type of innovation in question and the nature of strategic interactions between entering suppliers. Analysis of underlying mechanisms further corroborates the interpretation of trade-offs involved in opening a technology.

The third essay attempts to more closely examine the economic mechanisms underlying the granting of access to a component by studying the effect of promoted entry into third-party software applications development. Fantastic numbers of software developer firms–thousands–entered in a pattern consistent with network effects acting between increasing entry of software developers and supply of software titles, and an increasing installed base of end-users. However, close examination of the data suggest that despite the presence of network effects, that growing entry did not have nearly as much effect on the overall selection of software titles offered to end-users as did the discretionary development decisions by individual developers. The analysis finds that larger developer networks in fact lead to fewer software titles generated. I interpret this result as consistent with diminished investment incentives of incumbent developers with the growing competition created by incremental entry to developer networks.

Bibliography

[1] Augereau, A., M. Rysman, et al. (2006). "Coordination versus Differentiation in a Standards War: The Adoption of 56K Modems." RAND Journal of Economics forthcoming.

[2] Baldwin, C. and K. Clark (2000). Design Rules Volume 1: The Power of Modularity, MIT Press.

[3] Becchetti, L. and L. Paganetto (2001). "The Determinants of Suboptimal Technological Development in the System Company-Component Producers Relationship", International Journal of Economic Organization 19(9): 1407-1421.

[4] Becker, G. and G. Murphy (1991). "The Division of Labor, Coordination Costs, and Knowledge." Quarterly Journal of Economics 107(4): 1137-1160.

[5] Chesbrough, H. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology, Harvard Business School Press.

[6] Cusumano, M. A., Y. Mylonadis, et al. (1992). "Strategic Maneuvering and Mass-Market Dynamics - the Triumph of VHS over Beta." Business History Review 66(1): 51-94.

[7] David, P. and S. Greenstein (1990). "The Economics of Compatibility Standards: An Introduction to Recent Research." Economics of Innovation and New Technology 1: 3-41.

[8] Economides, N. (1996). "Network Externalities, Complementarities, and Invitations to Enter." European Journal of Political Economy 12: 211-233.

[9] Farrell, J. and M. L. Katz (2000). "Innovation, Rent Extraction, and Integration in Systems Markets." Journal of Industrial Economics 48(4): 413-32.

[10] Gawer, A. and M. Cusumano (2002). Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation, Harvard Business School Press.

[11] Grindley, P. (1995). Standards Strategy and Policy: Cases and Stories. Oxford, Oxford University Press.

[12] Grossman, S. and O. Hart (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration." Journal of Political Economy 94(4): 691-719.

[13] Katz, M. and C. Shapiro (1986). "Technology Adoption in the Presence of Network Externalities." Journal of Political Economy 94(4): 823-841.

[14] Katz, M. and C. Shapiro (1994). "Network Externalities, Competition, and Compatibility." American Economic Review 75(3): 424-40.

[15] Kende, M. (1998). "Profitability under an Open versus a Closed System." Journal of Economics & Management Strategy 7(2): 307-326.

[16] Langlois, R. N. (1992). "Creating External Capabilities: Innovation and Vertical Disintegration in the Microcomputer Industry." Business and Economic History 19: 93-102.

[17] Marschak, T. (1962). Strategy and Organization in a System Development Project. The Rate and Direction of Inventive Activity: Economic and Social Factors. R. Nelson. Princeton, N.J., Princeton University Press: 549-586.

[18] Matutes and Regibeau (1988). "Mix and Match: Product Compatibility Without Network Externalities." RAND Journal of Economics 19(2): 219-234.

[19] Nahm, J. (2004). "Open Architecture and R&D Incentives." Journal of Industrial Economics 52(4): 547-568.

[20] Richardson, G. (1972). "The Organisation of Industry." Economic Journal 82(327): 883-896.

[21] Shapiro, C. and H. Varian (1998). Information Rules: A Strategic Guide to the Network Economy. Boston, Harvard Business School Press.

[22] Teece, D. (1986). "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy." Research Policy 15: 285-305.

[23] von Burg, U. (2001). The Triumph of the Ethernet. Stanford, Stanford University Press.

[24] von Hippel, E. (2005). Democratizing Innovation. Cambridge, MIT Press

[25] West, J. (2004). "What are Open Standards? Implications for Adoption, Competition and Policy." Working Paper.

[26] Williamson, O. (1975). Markets and Hierarchies: Analysis and Antitrust Implications. New York, Free Press.